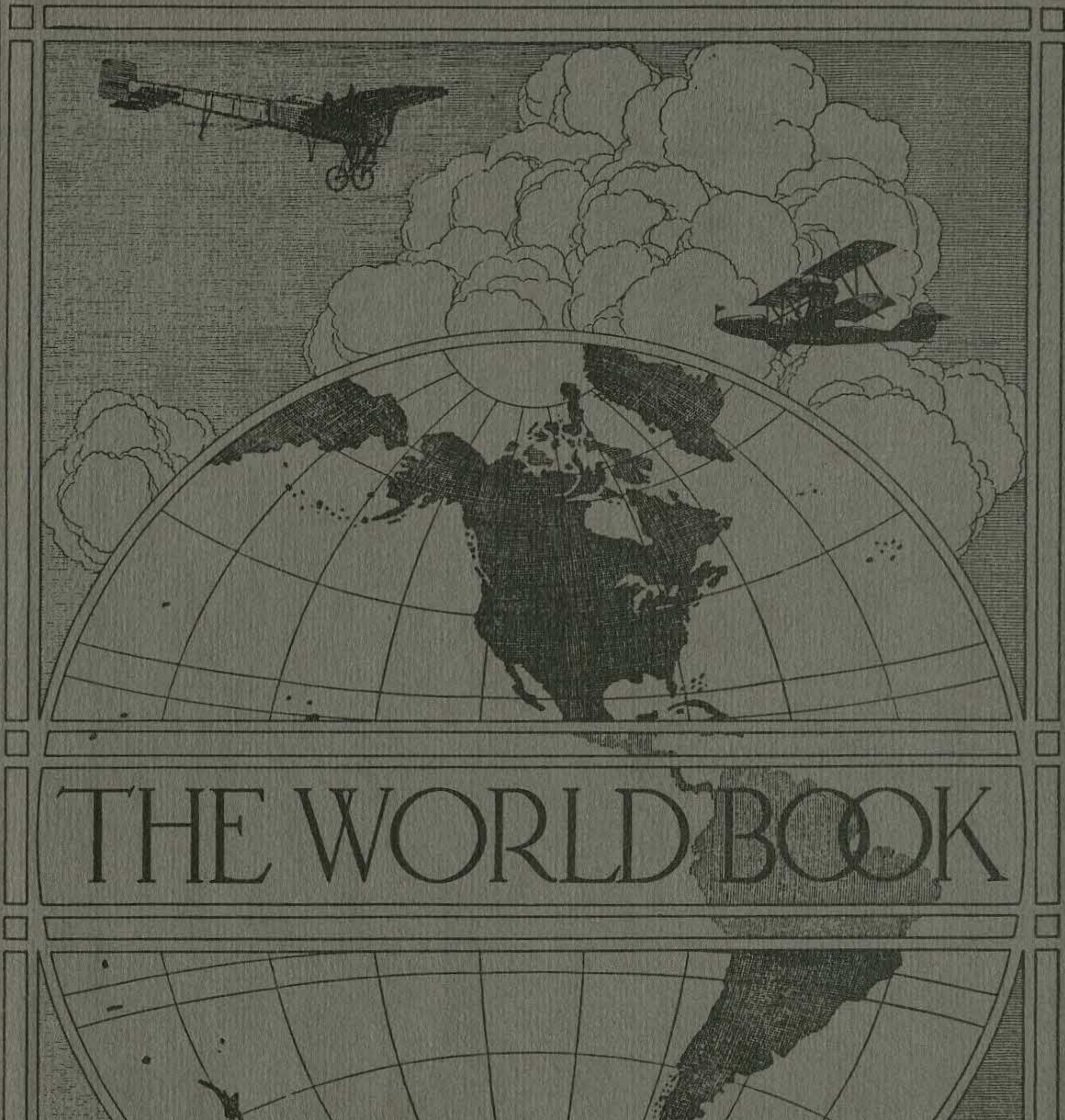
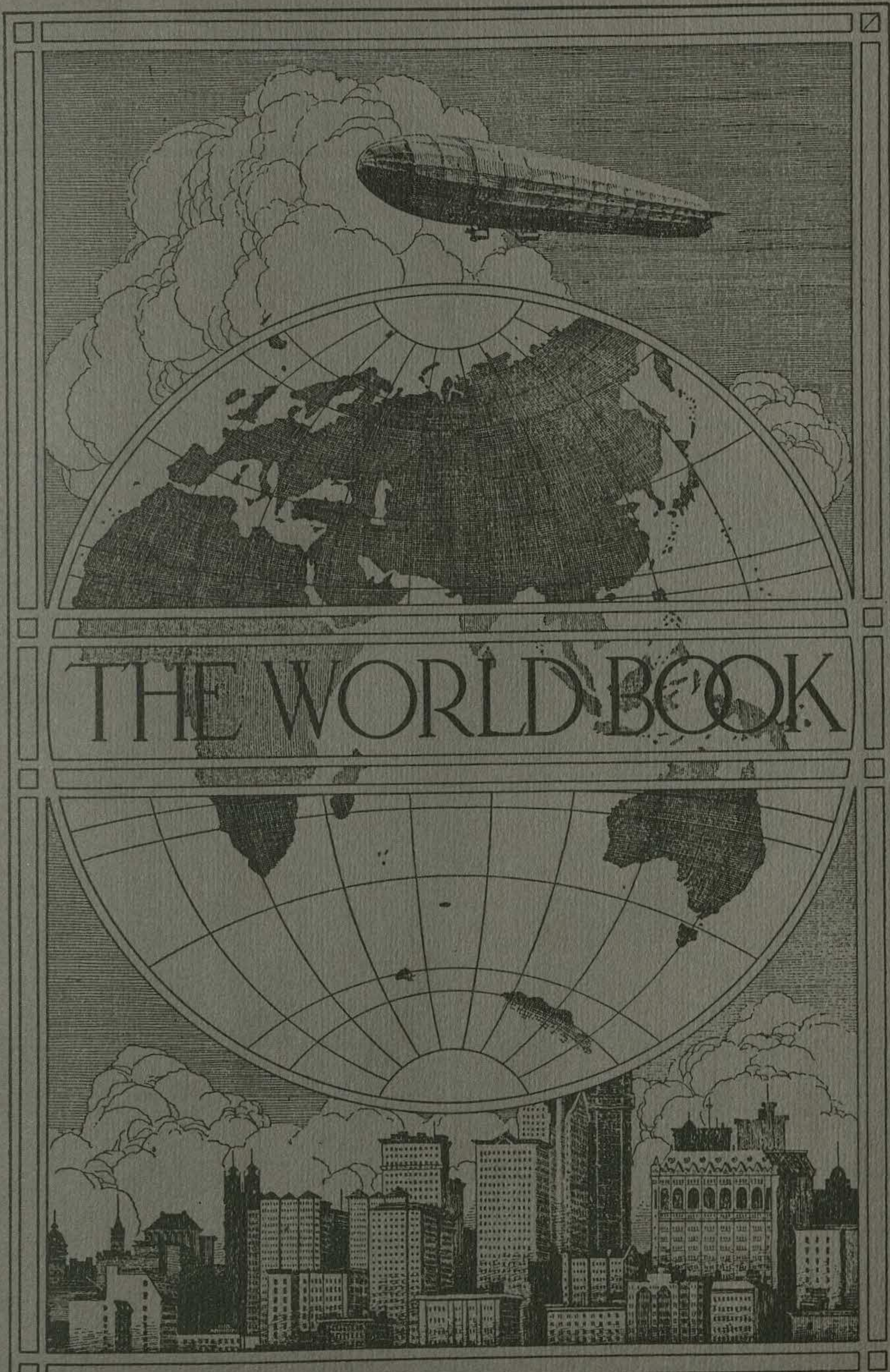
THE WORLD BOOK

THE WORLD BOOK




THE WORLD BOOK

T Volume 19

49
19

The World Book Encyclopedia

S.C.E.R.T. West Bengal
Library
25/3, B.C. Road

World Book International
World Book Inc.
A Scott Fetzer company
London Sydney Tunbridge Wells Chicago

The World Book Encyclopedia
(International)

© 1996, 1995, 1994, 1993, 1992, World Book, Inc. All rights reserved. This volume may not be reproduced in whole or in part in any form without prior written permission from the publisher.

22. 6. 2010
14030

"World Book" Reg. U.S. Pat. & T.M. Off. Marca Registrada

ISBN 0-7166-6696-0

Library of Congress Catalog Card Number 95-61137

Printed in the United States of America

1 2 3 4 5 99 98 97 96

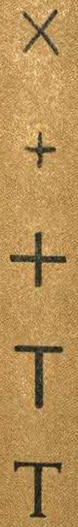
Tt

T is the 20th letter of the English alphabet. It was also a letter in the alphabet of the Semites, who once lived in Syria and Palestine. They called the letter *taw,* their word for *mark.* They used a cross-shaped mark they may have borrowed from an Egyptian *hieroglyphic,* or picture symbol, used as a check mark. The Greeks borrowed the letter from the Phoenicians. However, when they adopted the letter, they moved the crossbar to the top of the vertical stroke. The Greeks called their letter *tau.* See **Alphabet.**

Uses. *T* or *t* is about the second most frequently used letter in books, newspapers, and other printed material in English. As an abbreviation in geographic names, it may stand for *territory* or *township.* As a musical abbreviation, *t* may indicate *tenor, tempo,* or *time.* In grammars and dictionaries, it means *tense* or *transitive.* It may also stand for *ton, temperature,* or *Testament,* as in *O.T.,* or *Old Testament.*

Pronunciation. A person pronounces *t* by placing the point of the tongue on the upper teethridge, with the lips and vocal cords open, and expelling the breath between the teeth and tongue. In such words as *fasten* or *castle,* the *t* is silent. In the combination *tion, t* may be pronounced *sh* as in *nation,* or *ch* as in *question.* In the combination *th,* as in *thin,* a person pronounces *t* by placing the tongue blade below the points of the upper teeth and expelling the breath between the tongue and teeth, with the vocal cords relaxed. In words like *thine,* the process is the same, but the vocal cords vibrate. See **Pronunciation.**

Development of the letter T



The ancient Egyptians used this check mark about 3000 B.C.

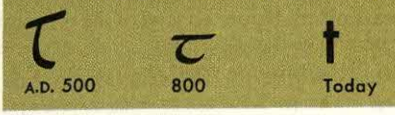
The Semites, about 1500 B.C., used a cross-shaped letter that they called *taw,* their word for *mark.*

The Phoenicians had a cross-shaped letter in their alphabet about 1000 B.C.

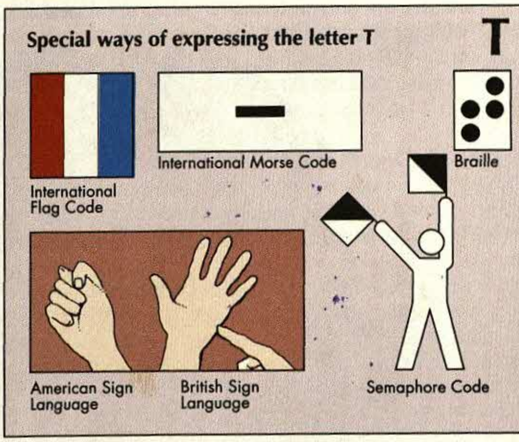
The Greeks, about 600 B.C., put the crossbar at the top of the vertical stroke. They called the letter *tau.*

The Romans gave the letter T its capital form about A.D. 114.

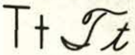
The small letter t developed during the A.D. 500's from Roman writing. The letter changed slightly in the 800's. By the 1500's, it had the form we use today.



Special ways of expressing the letter T

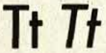


Common forms of the letter T



Handwritten letters vary from person to person. *Manuscript* (printed) letters, *left,* have simple curves and straight lines. Cursive letters, *right,* have flowing lines.

Roman letters have small finishing strokes called *serifs* that extend from the main strokes. The type face shown above is Baskerville. The italic form appears on the right.



Sans-serif letters are also called *gothic letters.* They have no serifs. The type face shown above is called Futura. The italic form of Futura appears on the right.

Computer letters have special shapes. Computers can "read" these letters either optically or by means of the magnetic ink with which the letters may be printed.

T cell. See **Thymus.**

Tabby. See **Cat** (Coat; picture).

Tabernacle, also called the Tent of Meeting, was the centre of worship of the Israelites during early Biblical times. According to the Book of Exodus, the Hebrews built the Tabernacle during their wanderings in the desert. It was to be a symbolic dwelling place for God within the Israelite camp or settlement. Other places of worship are sometimes called tabernacles.

While on Mount Sinai, Moses received instructions for building the Tabernacle. The materials were provided by the free offerings of the people. The Tabernacle was dedicated on the first day of the second year after the Israelites fled from Egypt on their way to the Promised Land (modern Israel).

According to the Bible, the place of worship was 14 metres long and had a height and width of 4.6 metres. Its framework of acacia wood was overlaid with fine gold. The ceiling was of white linen with figures of blue, purple, and scarlet angels woven into it. The structure was covered with a curtain of goat's hair and a layer of skins. A veil of linen divided the inside into two sections, the Holy of Holies and the Holy Place. The Holy of Holies contained the Ark of the Covenant, which held the Tables of the Law—the Ten Commandments.

The Ark was called the Ark of the Covenant because it was a symbol of the Jews' *covenant* (agreement) with God. Above the Ark was a cover of gold with a figure called a cherub at each end. In the Holy Place were the table of the *shewbread* (bread made without yeast), the altar of incense, and a candlestick, all made of gold.

The Tabernacle stood within a court, enclosed by rich curtains and brass pillars. It opened toward the east and faced the altar where the people brought their sacrifices to be offered by the priests. The court also contained a *laver* (basin), where the priests washed their hands and feet before entering the Holy Place.

The Tabernacle could be carried from place to place. The Bible reports that it was moved from the desert to Gilgal, then to Shiloh after the Israelites conquered Canaan. Later, it was moved to Jerusalem, where its relics were preserved in Solomon's Temple.

See also **Ark of the Covenant; Mormons** (picture: The Mormon Tabernacle); **Temple.**

Tabernacles, Feast of. See **Sukkot.**

Tabes means a wasting away of the body. It once was used to describe any condition that caused such wasting. But its modern usage is almost exclusively to describe the wasting caused by syphilis, one of the venereal diseases (see **Sexually transmitted disease**). In this condition it is called *tabes dorsalis,* meaning a wasting away of the *dorsal* (back) part of the spinal cord. Persons with tabes dorsalis have difficulty coordinating their movements. They may lose all feeling in their arms and legs, and their leg muscles deteriorate. The *optic nerve,* an eye nerve, may be affected.

Table Mountain is one of South Africa's best known landmarks. This flat-topped mountain rises behind the city of Cape Town, overlooking Table Bay. The highest point, Maclear's Beacon, is 1,086 metres above sea level. Table Mountain can be seen from ships up to 200 kilometres away. The mountain is a national monument and is floodlit at night. A cableway built in 1929 carries some 250,000 passengers a year up the mountain.

Table Mountain consists of shale and sandstone. Hard, resistant quartz in the sandstone led to the formation of the flat top after softer rock was worn away.

The Portuguese admiral, Antonio de Saldanha, called the Table Bay area *Taboa do Cabo* (Table Cape or Head) in 1503.

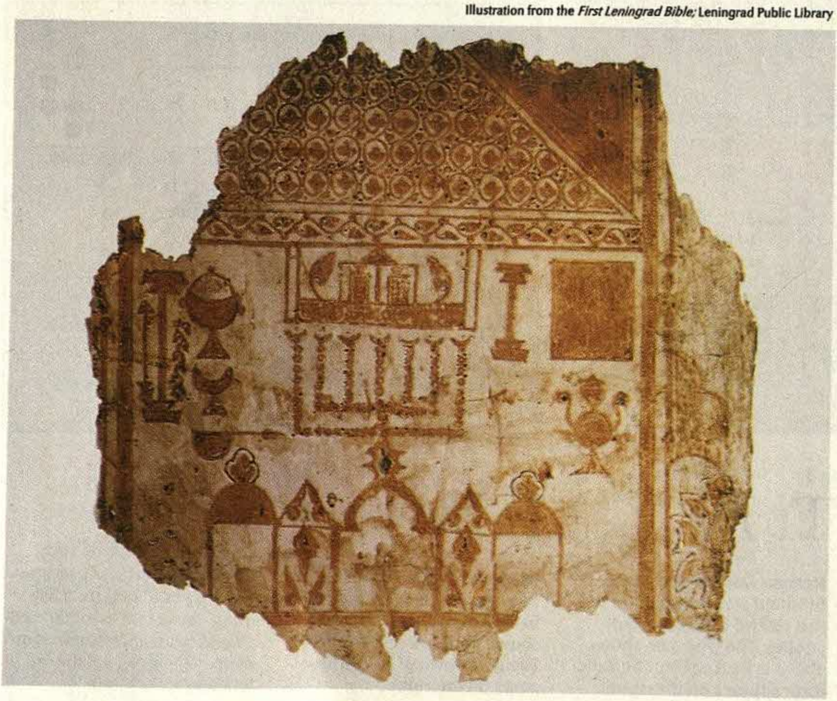


Illustration from the *First Leningrad Bible;* Leningrad Public Library

The Tabernacle was an ornate portable place of worship that the Israelites built during their wanderings in the desert. This fragment from a Bible dating from A.D. 929 shows the Tabernacle and its implements. A fence with a triple gate encloses the Tabernacle. In the centre, a sacred candlestick called a *menorah* appears in the court, beneath the Ark of the Covenant.

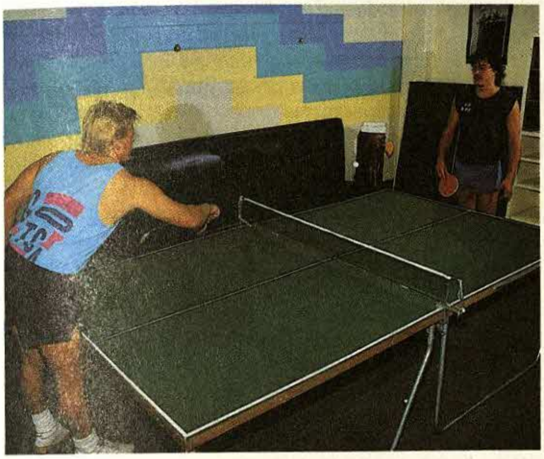
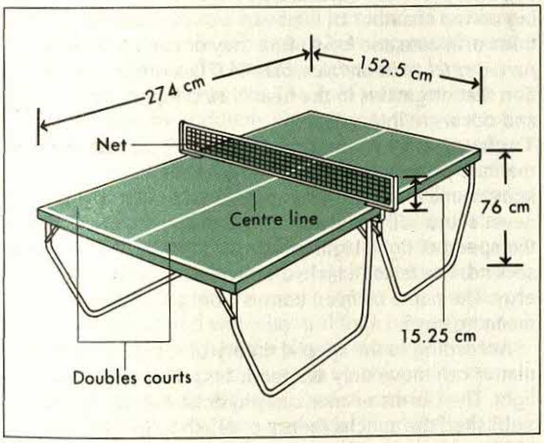
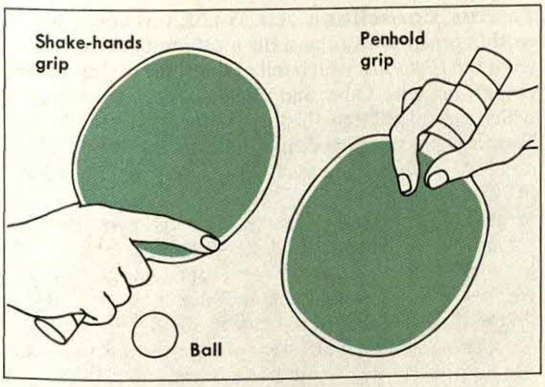


Table tennis, also called *ping-pong,* provides indoor recreation for people of all ages. Many schools and youth clubs have table tennis tables, which can be used by two or four players.



A table tennis table is divided into halves by a low net. A white centre line further divides the surface of the table into four courts, which are used when playing doubles.



Two ways to hold a table tennis racket are shown above. The *shake-hands grip* is used by most players in Western countries.

Table tennis, or ping-pong, is a lively indoor game that resembles a miniature version of tennis. The players use rackets, which are often called *bats* or *paddles,* to hit a ball back and forth over a net that stretches across a table. They score points by hitting the ball so their opponent or opponents cannot return it. Table tennis may be played by two or four persons. If two persons play, the game is called *singles.* If four play, the game is called *doubles.*

Table tennis developed in England during the late 1800's. Today, it is a popular form of recreation and an international sport. Players from more than 100 countries belong to the International Table Tennis Federation (ITTF). The ITTF holds a world championship tournament every two years.

Equipment for table tennis consists of a table, net, rackets, and ball. The table measures 274 centimetres long, 152.5 centimetres wide, and 76 centimetres high. Most tables are dark green with a white line along the edges. A white centre line runs the length of the table. The centre line divides the table into *courts* that are used for doubles. The net, which is suspended between two posts, extends across the width of the table at its centre. The net measures 15.25 centimetres high.

The rackets may be any shape, size, or weight. All are made of wood and are covered with pimpled or smooth sponge. Each side must be of a uniform dark colour, though the sides may be different colours. The covering material cannot be more than 4 millimetres thick on either side of the racket.

The ball is round and hollow and made of celluloid. It measures 38 millimetres in diameter and weighs 2.5 grams.

How the game is played. Table tennis players toss a coin to determine who serves first. The server places the ball on the palm of the hand, throws it up vertically, and hits it with the racket. When throwing the ball, the server must keep the fingers straight and together, and the thumb extended. The hand must be behind the end of the table when the server hits the ball. The ball must bounce on the server's side of the net, clear the net, and bounce on the opponent's side.

For a good return, a player must hit the ball after one bounce so that it clears the net and bounces on the opponent's court. *Volleying* (hitting the ball before it bounces) is not allowed. Play continues until one person misses the ball, hits it off the table, or hits it into the net. When a player fails to make a good serve or a good return, the opponent scores a point. After every five points, the other player serves.

The player who first scores 21 points wins the game. However, the winner must have at least a two-point lead. If both players score 20 points, they alternate serving after each point until one person leads by 2 points. A match consists of either two out of three games or three out of five games.

When playing doubles, the server must serve from his or her right-hand court into the opponents' right-hand court. The teammates must alternate in hitting the ball on the returns.

Tabloid. See Newspaper (Kinds of newspapers).

Taboo is an action, object, person, or place forbidden by law or culture. The word *taboo* comes from the Polynesian word *tapu,* or *tabu,* which means *something sa-*

cred, special, dangerous, or *unclean.* Many societies believe that people who go to a taboo place or touch a taboo object will suffer serious injury. Society may also punish the offenders or may consider them to be taboo.

Sacred objects or people are taboo because they supposedly have a mysterious force that enables them to injure or kill a person. Unclean objects are taboo because they supposedly bring evil to a person or group.

People in many parts of the world avoid taboos. Until the 1900's, for example, Fiji Islanders could not touch any article that belonged to the tribal chief or priest. Australian Aborigines must not say the name of a dead person aloud. Muslims and Orthodox Jews must not eat pork or shellfish. Societies in many parts of the world consider *incest* taboo. These societies forbid marriage or sexual relations between closely related people, such as a brother and sister.

See also **Magic** (The magician; Homeopathic magic); **Mythology** (Mythology of the Pacific Islands).

Tabriz (pop. 852,296) is the fourth largest city in Iran. It is the capital of East Azerbaijan province, in the northwestern corner of Iran. It lies about 55 kilometres from Lake Urmia, and is almost surrounded by mountains. For location, see **Iran** (map). Earthquakes have nearly destroyed Tabriz several times. In 1990, a major earthquake struck the city, causing thousands of deaths and extensive property damage.

Tabriz is famous for its fine Persian rugs, and has a large trade in dried fruits and leather goods. It also produces matches, flour, and textiles.

Historians do not know exactly when the city was founded, but it was probably before the A.D. 300's. It served as Iran's capital for a short time in the early 1500's. Russian troops occupied Tabriz in 1827, and again during World Wars I and II.

Taché, Sir Étienne-Paschal (1795-1865), was a Canadian statesman. He served twice as prime minister of the Province of Canada, and presided over the Quebec Conference of 1864 that paved the way for the federation of the British North American colonies.

Taché was born in St. Thomas, Quebec, Canada. He graduated from the Quebec Seminary. After serving in the British militia during the War of 1812, he practised medicine. In 1841, Taché entered the Legislative Assembly of Canada. He later served as commissioner of public works, member of the legislative council, and receiver-general. He was knighted in 1858.

Taché formed a cabinet with John A. Macdonald in 1856, and became prime minister. In 1864, the two men again formed a cabinet with Taché as prime minister. But Macdonald was the real head of the government in both ministries.

See also **Macdonald, Sir John A.**

Tachometer is a device that is used for measuring the speed of rotation of a spinning shaft or wheel, usually in terms of revolutions per minute (rpm). Tachometers often are used to measure engine rpm in cars, ships, and aircraft. Tachometers indicate an engine's power and its efficiency in converting energy into mechanical force.

The *drag-type tachometer* is widely used in cars. It consists of a permanent magnet connected to the car's crankshaft and an aluminium disc attached to a spring near the magnet. As the crankshaft turns, it causes the magnet to rotate, thus producing a rotating magnetic field. This field creates small electric currents that cause the disc to turn. As the engine's speed increases, the rotation of the disc increases proportionally. A pointer attached to the disc indicates the engine's rpm on a dial on the dashboard.

A *digital tachometer* measures rpm by means of a pulse accompanying each rotation of the crankshaft. A meter counts the number of pulses per minute, which equals rpm.

For some moderately high-speed machines, a tachometer consisting of a set of vibrating reeds may be used. The reeds resemble teeth of a comb. Each reed vibrates at just one frequency. By noting which reed is shaking, a person can tell how fast the machine is vibrating and, thus, how fast it is turning. *Reed tachometers* are used on steam turbines and engines.

An *electric tachometer* is commonly used in aeroplanes. It consists of a voltage generator turned by the engine and connected by wires to a voltmeter. The voltmeter shows engine rpm.

Tachycardia is an unusually fast heartbeat, sometimes referred to as *palpitations.* The disorder is usually organic. There are several types of tachycardia, depending on the chamber of the heart from which the palpitations originate and how often they occur. For example, *paroxysmal atrial tachycardia (PAT)* is a rapid heart action that originates in the heart's *atria* (upper chambers) and occurs at intervals.

Tachyon is a hypothetical elementary particle. An elementary particle is a subatomic particle that has no known smaller parts. If tachyons exist in nature, they never stand still but always move at speeds greater than the speed of light. Light travels at 299,792 kilometres per second. The faster a tachyon travels, the lower its energy. The name *tachyon* comes from a Greek word meaning *swift.*

According to the special theory of relativity, ordinary matter can move only at speeds less than the speed of light. The German-American physicist Albert Einstein published the special theory of relativity in 1905. But in 1962, several physicists realized that the existence of particles that travel faster than light is not necessarily incompatible with Einstein's theory. No convincing experimental evidence has been found for the existence of tachyons.

Tacitus, Cornelius (c. A.D. 55-120), was one of the world's greatest historians. His most important works were the *Histories,* which tell of the short reigns of the emperors Galba, Otho, and Vitellius; and the *Annals,* which describe Roman history from Augustus to Nero. Tacitus favoured the republican form of government, and his *Histories* and *Annals* were extremely critical of the Roman emperors. He condemned them in sharp, unforgettable phrases, and overlooked any merits of the imperial system. The *Histories* and *Annals* cover periods for which our other sources are scanty. Another work, *Germania,* is important because it contains one of the first written accounts of the customs and habits of the Germanic peoples, who later spread over most of western Europe. He also wrote *Life of Agricola* and *Dialogue on Orators.*

Tacitus was probably born in northern Italy. He led an active public life and was *consul* (chief magistrate) in

A.D. 97. He served as governor of the Roman province of Asia in 112 and 113.

Tack. See **Horse** (Riding equipment).

Tackle. See **Block and tackle.**

Tacloban (pop. 137,190) is the chief city of Leyte Island in the Philippines. It overlooks the San Juanico Strait that separates the northeast corner of Leyte from Samar Island. For location, see **Philippines** (map). The city is the trading centre and chief port for an area that produces abacá, rice, coconuts, and tobacco.

Taco. See **Mexico** (Food).

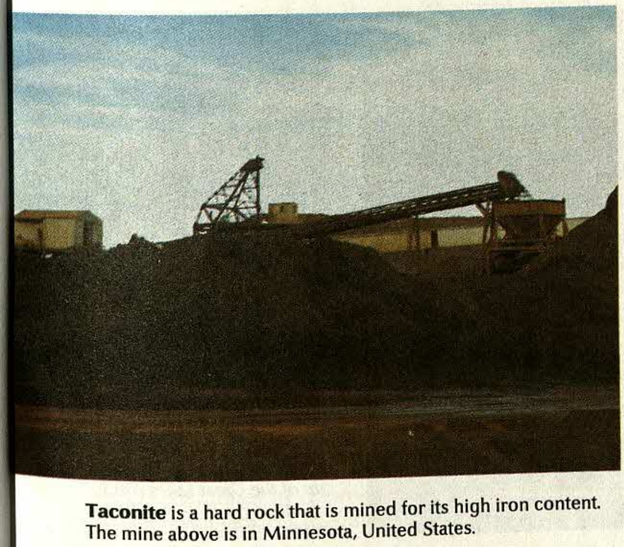
Taconite is a hard rock that contains about 30 per cent iron in the form of fine specks of iron oxide. The rest of the rock consists of a mineral called *chert.*

Taconite is found in large quantities in the Mesabi Range of Minnesota, U.S.A. It is the mother rock from which the great Mesabi iron-ore deposits were formed. These important iron-ore deposits lie like raisins in a great cake of taconite, 160 kilometres long and about 1.5 to 3 kilometres wide. The iron in taconite occurs principally as the black oxide *magnetite,* or *loadstone,* and the red oxide *haematite.*

Taconite is so hard that ordinary drilling and blasting methods cannot be used to obtain it. In one method of processing taconite, miners use a jet piercing machine, which shoots alternate streams of burning paraffin and cold water. The paraffin heats the taconite to about 2600° C, making it white hot. The cold water jet then cracks the rock by suddenly changing its temperature. The taconite can then be blasted into chunks.

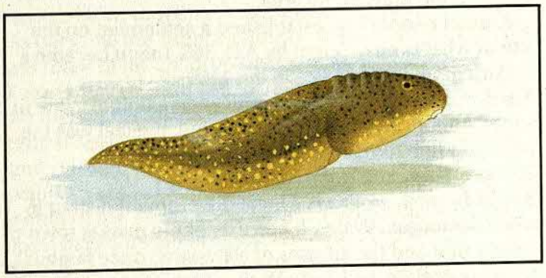
Taconite next goes through several stages of crushing, until the pieces are less than about 20 millimetres in size. Cylinders grind it down into even smaller pieces, and magnets separate the useful taconite from the sand. After the taconite has been ground almost to a powder and purified, it is fed into a steel barrel. The particles of taconite, when mixed with clay and then heated, form marble-sized balls. When the clay burns away, the taconite marbles are strong enough to be shipped to the blast furnaces, where they are used to make iron.

See also **Haematite; Iron and steel** (Kinds of iron ore; Processing); **Loadstone.**



Taconite is a hard rock that is mined for its high iron content. The mine above is in Minnesota, United States.

Eggs of the common European frog are jellylike and transparent. Inside each egg is an unborn tadpole. The rounded head and long tail of some of them have already formed.



A newly hatched tadpole resembles a small fish. Gradually, the animal develops the physical traits of a mature frog or toad. The tadpole stage may last only 10 days or as long as 2 years.

Tactile sense. See **Touch.**

Tadpole is an immature frog or toad. A tadpole is a *larva,* which is an early stage of an animal. Tadpoles live in water. When a tadpole hatches from its egg, it looks like a small fish. As the tadpole grows, it gradually develops the physical characteristics of the mature animal. The process of changing from a larva to an adult is called *metamorphosis.* The tadpole stage may last from 10 days to more than 2 years, depending on the species.

Tadpoles live in shallow waters wherever frogs and toads are found. Most tadpoles inhabit ponds, lakes, or slow-moving rivers. The greatest variety of tadpoles are found in the tropics. Tadpoles hatch from a jellylike mass of eggs laid in the water. A tadpole has a large, rounded head and a long, flat tail. The animal uses the tail to propel itself through the water. Tadpoles breathe by means of gills. Most tadpoles eat plants.

Most tadpoles are dark-coloured, ranging from solid black in common toads to olive-green in some frogs. Tadpoles of most species are less than 2.5 centimetres long. Bullfrog tadpoles are over 10 centimetres long. Tadpoles of the paradoxical frog of South America grow to lengths of over 25 centimetres.

A tadpole has no legs when it hatches, but it begins to grow hind legs during the first stages of metamorphosis. Gradually, the tadpole's head flattens and the tail becomes shorter. The digestive system changes, enabling the animal that develops to eat insects and other animals. During the final stages of metamorphosis, the front legs of the tadpole appear. The gills disappear as lungs develop, forcing the tadpole to gulp air at the water's surface. The animal absorbs the remaining part of the tail after emerging from the water to become a land-living adult.

See also **Frog** (with pictures); **Toad.**

Tadzhikistan. See Tajikistan.

Taegu (pop. 2,030,672) is the third largest city in South Korea. Only Seoul and Pusan have more people. Taegu lies in southern South Korea (see **Korea** [map]). The city is a commercial and educational centre.

Taegu stands on a fertile plain and is surrounded by high mountains on the north and south. Its landmarks include the Talsong fortress, constructed during the Iron Age (1500-1000 B.C.), and many Confucian shrines. The city has two universities, a women's college, and several technical schools. Buddhist monasteries lie in the mountains around Taegu. The city ranks as South Korea's largest producer of textiles, and it is a market for farm products and minerals of the area.

Korean people had established a settlement on the site of what is now Taegu by A.D. 366. Taegu became a major commercial centre in the 1400's.

Tael was a Chinese weight indicating a unit of value in silver. Although its worth often varied, the tael was the basis of value for Chinese money until 1935.

Tafari, Ras. See **Haile Selassie I.**

Taff-Ely (pop. 95,400) is a local government district in Mid Glamorgan, Wales. It consists of the market town of Pontypridd and the villages of Nantgarw, once famous for its porcelain, and Taff's Well, a former spa. Pontypridd, Pontyclun, Treforest, and Llantrisant are expanding industrial centres. The British Royal Mint is at Llantrisant. Llantrisant Old Town is a hill top settlement with remains of a castle built in the 1100's. Taff-Ely also includes the former mining towns of Gilfach Goch, Llanharan, and Tonyrefail. See also **Glamorgan.**

Taffeta is a smooth, rather stiff cloth of rayon, nylon, or silk. The name *taffeta* comes from the Persian word *taftah,* meaning *twisted* or *woven.* Taffeta has a plain, close weave. It comes in broad widths for making clothing, bedspreads, and draperies, and in narrow widths for making ribbons.

Taft, Lorado (1860-1936), was an American sculptor, teacher, and writer. He is best remembered for *The History of American Sculpture* (1903), the first book on the subject. Taft's most famous sculptures are large, symbolic outdoor groups. They include *Fountain of Columbus* (1912) in Washington, D.C., *Fountain of the Great Lakes* (1913) and *Fountain of Time* (1922) in Chicago, and *Thatcher Memorial Fountain* (1917) in Denver. In 1911, Taft completed a giant outdoor statue of the Indian chief Black Hawk near Oregon, Illinois, U.S.A.

Taft was born in Elmwood, Illinois, and studied art in France. He established a studio in Chicago and taught at the Art Institute of Chicago and the University of Illinois from 1886 to 1929.

Taft, William Howard (1857-1930), was president of the United States from 1909 to 1913. He is the only man in the history of the U.S. who served first as president, then as chief justice. Taft did not want to be president. At heart, he was a judge and had little taste for politics. Above all, he wanted to be a justice of the Supreme Court of the United States.

Early life. Taft was born on Sept. 15, 1857, in Cincinnati, Ohio, U.S.A. He graduated from Yale College in 1878 and earned a law degree from Cincinnati Law School in 1880. From 1881 until 1900, he worked mainly as a lawyer or judge.

Taft was governor of the Philippines, then a U.S. colony, from 1900 to 1904. He developed the educational, legal, and public transportation systems there, and worked to establish some self-government for the colony.

In 1904, Taft became secretary of war in President Theodore Roosevelt's cabinet. Roosevelt decided not to seek reelection in 1908, and recommended Taft, who became the Republican presidential candidate. Taft easily defeated the Democratic candidate, newspaper editor William Jennings Bryan.

Lorado Taft, *above,* was a popular American sculptor in the early 1900's. He became known for his large outdoor sculpture groups. His *Fountain of the Great Lakes* (1913), *left,* stands outside the Art Institute of Chicago.

During Taft's presidency, the government took action against *trusts* (business monopolies), and passed laws to make trade fairer. The United States sought to increase its international influence by expanding trade. Taft stood for reelection in 1912, but this time was opposed by Roosevelt. The election was won by a Democrat, Woodrow Wilson. Taft left the presidency in March 1913, and became a law professor at Yale University.

In 1921, President Warren G. Harding appointed Taft chief justice of the U.S. Supreme Court, thus fulfilling his long-held ambition.

See also **Roosevelt, Theodore.**

Taglioni, Marie (1804-1884), was one of the most famous ballerinas of the early 1800's. She was the first ballerina to make toe-dancing beautiful. Her leaps are described as slow flights through the air. To audiences, the effortless grace of her movements made her appear weightless. Her dancing and her acting looked effortless and cool.

Taglioni was born in Stockholm, Sweden. She was trained by her father, Filippo Taglioni, an Italian dancer and *choreographer* (dance composer). Her dancing in his ballets, particularly in *La Sylphide* (1832), started the romantic period in ballet which lasted until the mid-1840's. Audiences all over Europe idolized her.

See also **Ballet** (Romantic ballet; picture).

Tagore, Rabindranath (1861-1941), one of the greatest poets of modern India, received the 1913 Nobel Prize for literature. A song that he composed for the Indian National Congress became the national anthem of India. Another of his songs "Amar Sonar Bangla" (My Golden Bengal) became the national anthem of Bangladesh.

Tagore's dignity and strength of character, and the energy and beauty of his art remain an inspiration to the people of Bengal. International appreciation of his genius declined after his death. But later, his reputation in Western countries grew again, because of new and accurate translations of his work.

Tagore wrote in the Bengali language. His collected poems, stories, novels, plays, and essays take up 26 volumes. He also composed more than 2,000 songs.

In all his works, he tried to express the divine and poetic spirit he saw in nature. He also attempted to understand the workings of society and history. He used many sources and traditions, from poetry written in the ancient, Indian language of Sanskrit to Western prose fiction. Some conservative commentators criticized his daring experiments with new styles and forms.

Tagore loved his country and worked tirelessly for its advancement. But he was never a narrow nationalist. He saw nationalism as one of the main causes of war. He detested British colonial rule in India. But he believed that India should learn from the best of Western civilization. In the early 1900's, the governor of India, Lord Curzon, decided to divide Bengal into two separate provinces. This provoked a movement opposed to the purchase of British goods. Tagore lent his support with speeches and patriotic songs. But he withdrew when the movement led to bomb attacks against the British and riots between Hindus and Muslims. In 1919, he protested against General Dyer's troops killing unarmed people at Amritsar by returning the knighthood the British had given him. His friendship with the Indian leader Mohandas Gandhi was complex. He acknowledged his greatness by giving him the title *Mahatma,* which means *Great Soul.* But he feared that Gandhi had let loose uncontrollable forces in India.

Tagore was born in Calcutta. His parents were members of one of the wealthiest and most cultured families of Bengal. His grandfather, known as "Prince" Dwarkanath Tagore, made a large fortune out of commercial opportunities that the British East India Company brought to India. His father, Debendranath Tagore, was a leading figure in the Brahmo Samaj movement, which tried to create a modern, rational form of Hinduism.

Rabindranath was his parents' fourteenth child. He grew up surrounded by talented brothers, sisters, and cousins. He resisted school and was taught mainly by private tutors. When he was 18, he made his first visit to the United Kingdom, where he studied law. After his return to India, he managed his family's estates in the Padma River region (now Bangladesh).

In 1901, Tagore founded an experimental school at Shantiniketan, 160 kilometres northwest of Calcutta. This school developed into Visva-Bharati, a university that aims to bring together Asian and Western cultures. In his personal life Tagore endured great sadness. His wife and three of his children died young.

Tagus River, also called *Tajo,* is the longest river of the Iberian Peninsula of southwest Europe. It rises in central Spain and flows west across Portugal to the Atlantic Ocean. The river is 1,007 kilometres long and drains an area of about 80,300 square kilometres. The mouth of the Tagus gives Lisbon, Portugal, one of the finest harbours in Europe.

Tahiti, an island in the South Pacific Ocean, is famous for its exotic beauty and tropical climate. It is the largest island in French Polynesia, a French overseas territory made up of several island groups. Tahiti is one of the 14 Society Islands. For location, see **Pacific Islands** (map). Papeete is the largest city and chief port of Tahiti. The city is also the capital of French Polynesia.

Tahiti gained worldwide fame as a tropical paradise through the works of many artists and writers who visited the island or lived there. The French artist Paul Gauguin portrayed Tahiti's lush beauty and peaceful atmosphere in many paintings. Many authors, including Herman Melville and James Michener of the United States and Robert Louis Stevenson of Scotland, wrote glowing descriptions of the island. Such works have helped make Tahiti popular with tourists.

Tahiti covers about 1,040 square kilometres. A broken coral reef surrounds the island. A strip of flat, fertile land lies along the coast, where most of the people live. The interior of the island is mountainous and almost entirely uninhabited. Heavy rainfall helps create many fast-flowing streams and spectacular waterfalls there. The island has much lush vegetation, including coconut palms and banana, orange, and papaya trees.

About 120,000 people live on Tahiti. Most of them are Polynesians or have mixed Polynesian and European ancestry. The population also includes a few thousand Chinese and a few hundred Europeans.

Many Tahitians live in or near Papeete and work in the tourist industry, which is the base of the island's economy. Tahiti's Chinese population controls much of the retail and shipping trade on the island. People in

Tahiti is an island in the South Pacific Ocean. The island is famous as a tropical paradise. Papenoo Beach, *left,* lies on the northern coast of Tahiti.

rural areas farm the land or work in the fishing industry. The farmers grow breadfruit, taro, and yams for their own use and produce small quantities of copra and vanilla for export.

The earliest inhabitants of Tahiti were Polynesians who came there from Asia hundreds of years ago. The first European to visit the island was the British sea captain Samuel Wallis in 1767. He claimed Tahiti for Great Britain. The next year, a French navigator named Louis Antoine de Bougainville landed on Tahiti and claimed it for France. Tahiti became a French protectorate in 1842 and a colony of France in 1880. In 1946, France declared the islands of French Polynesia to be a French overseas territory. Several independence movements began in French Polynesia during the mid-1900's, but most of the people want to remain under French rule.

See also **Gauguin, Paul; Society Islands.**

Tahr is a shy animal rather like a goat, which lives in the Himalaya of northern India and Nepal. Tahrs are about 1 metre long, with shaggy brown hair. They have long, curved horns and hoofed feet. Tahrs live in large groups in steep mountainous areas. They feed on grass and other plants.

Scientific classification. Tahrs belong to the family Bovidae. They are *Hemitragus jemlahicus.*

Taiga. See **Forest** (Kinds of forests).

Taika reform. See **Japan** (History).

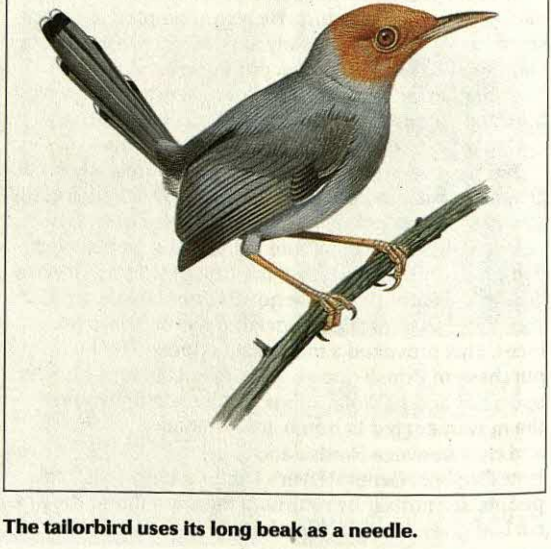
Tail is the part of the body of a vertebrate animal that extends backward beyond the pelvis. In animals without limbs, the tail is the part of the body that extends beyond the anus. The term *tail* includes both the fleshy portion and the outgrowths it may have, such as fins and feathers.

Animals use their tails in many ways. The tails of most water animals serve to move them and to steer them. Squirrels use their tails to keep their balance when they are leaping and climbing. Woodpeckers and kangaroos prop themselves up with their tails. Spider monkeys and opossums grasp things with their tails.

Tailorbird is a songbird found in tropical regions of China, India, Malaya, and the Philippines. Its name comes from the way it builds its nest in a large folded leaf. It sews the edges of the leaf together with strips of silk or wool thread, or vegetable fibre, using its beak as a needle. The nest inside the leaves is made from plant down, fine grass, and hair. The female lays three or four eggs. They range in colour from reddish-white to bluish-green and are marked with brownish-red. Tailorbirds are 10 to 15 centimetres long. There are nine species.

Scientific classification. Tailorbirds belong to the subfamily Sylviinae of the family Muscicapidae. They are genus *Orthotomus.*

See also **Bird** (picture: Kinds of bird nests).



The tailorbird uses its long beak as a needle.

Taine, Hippolyte Adolphe (1828-1893), was a French intellectual and critic. His application of the philosophy of *determinism* to art and literature did much to shape French intellectual attitudes in the 1800's.

To understand the origin and development of an artist's or writer's work, Taine said we must discover all the significant facts about the person's *race* (heredity), *milieu* (environment), and *moment* (state of the artistic tradition in which the person worked). Through this theory and through his emphasis on documentation, Taine greatly influenced the naturalist movement in literature (see **Naturalism**). Taine's *History of English Literature* (1863) and *Philosophy of Art* (1865-1869) illustrate his deterministic philosophy. His *Origins of Contemporary France* (1875-1893) blames the French Revolution for the decline he saw in France's greatness.

Taine was born in Vouziers, France. He was a professor at the École des Beaux-Arts in Paris almost continuously from 1864 to 1883.

Taipan is Australia's largest and most feared venomous snake. Taipans are among the deadliest snakes in the world. They can grow more than 3 metres in length, but most are less than 2 metres long. Taipans are rich brown to almost black on top, and cream or yellow with orange spots underneath. They live in New Guinea, and in most parts of Queensland and in Arnhem Land, Australia. They are found in a great variety of places, from coastal forests to the arid interior. Like brown snakes, but unlike Australia's other dangerous snakes, taipans lay eggs. Taipans feed largely on other reptiles and small mammals.

Scientific classification. The taipan belongs to the family Elapidae. They are *Oxyuranus scutellatus.*

Taipei (pop. 2,637,100) is the capital and largest city of the island country of Taiwan. It lies on the Hsintien, Keelung, and Tanshui rivers at the north end of the island of Taiwan. For location, see **Taiwan** (map). The name *Taipei* means *north Taiwan.*

Taipei and its surrounding area make up the commercial, cultural, and tourist centre of Taiwan. Taipei's landmarks include Chiang Kai-shek Memorial Hall; the Lungshan Temple, which is believed to be the oldest Buddhist temple in the city; and the Grand Hotel, which resembles an ancient Chinese palace. The city's National Palace Museum houses an outstanding collection of Chinese art. Taipei has large department stores and exotic bazaars. It is the home of several universities, including National Taiwan University, National Taiwan Normal University, and National Chengchi University.

Taipans are Australia's most dangerous snakes. They live in most parts of Queensland and in Arnhem Land in the Northern Territory, and also in New Guinea.

In 1967, Taipei annexed the towns of Chingmei, Mucha, Nankang, Neihu, Shihlin, and Peitou. As a result, the city grew from 67 to 272 square kilometres.

Taipei is one of the most densely populated cities in the world. Overcrowded housing is a problem in the city. Many high-rise buildings have been erected in Taipei, with little concern for planning laws. Heavy traffic is another problem. Air pollution has resulted from motor vehicles and from the numerous factories in and around the city.

Products made in Taipei include textiles, electrical machinery and appliances, wires and cables, refrigerators, motorcycles, rubber goods, and various handicrafts. More than a dozen airlines serve the nearby Chiang Kai-shek International Airport. Railways and buslines connect the city to all parts of Taiwan.

The Chinese began making large settlements in Taiwan during the 1600's. They founded Taipei in 1708. Japan took control of Taipei and the rest of Taiwan from China in 1895. The Japanese made Taipei the administrative and economic centre of the island and greatly expanded the city's area.

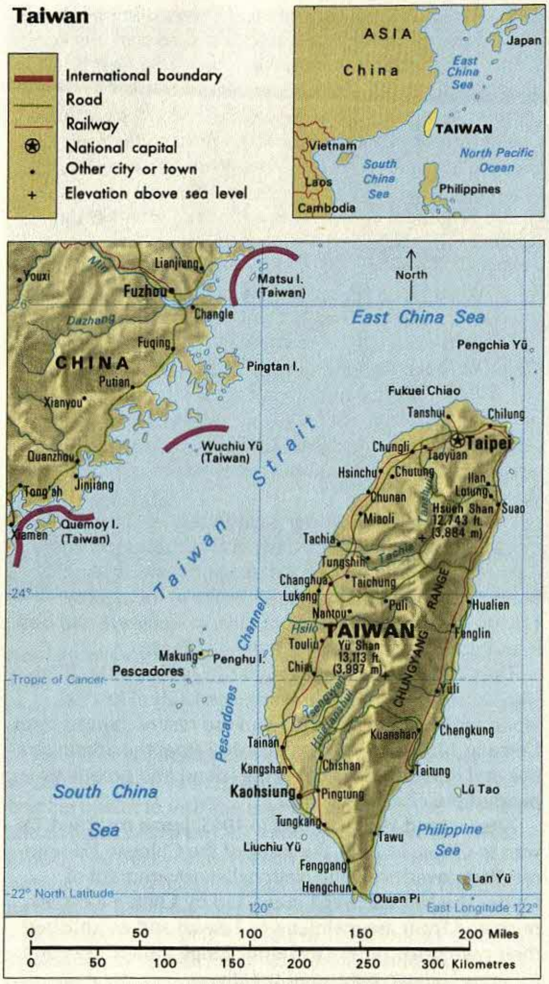
After World War II ended in 1945, Japan returned Taiwan to China. In 1949, the army of the Chinese Communist Party overthrew the Nationalist government of China. The Nationalist Chinese, led by Chiang Kai-shek, retreated from the mainland to Taiwan and established their own government in Taipei. Since then, Taipei and its suburbs have expanded greatly.

Taira was the name of a family that ruled Japan from about 1160 to 1185. The family is also known by its Chinese name, Heike. After the emperor lost his political influence in the late 700's, powerful families fought for control of the government. The Taira family became a leader of this new warrior class that ruled the country until 1867.

Taira Kiyomori, the head of the family, seized control of the government in about 1160. Through arranged marriages, Kiyomori's grandson became heir to the throne as Emperor Antoku. After Kiyomori died in 1181, the family's power declined. Taira rule ended in 1185, when the family was defeated in a sea battle by its main rival, the Minamoto family. The young Emperor Antoku drowned in the battle.

Taiwan is a mountainous island in the South China Sea, about 140 kilometres off the Chinese coast. The Chinese call the island *Taiwan,* meaning *terraced bay.* The wild, forested beauty of the island led Portuguese sailors in 1590 to name it *Ilha Formosa,* meaning *beautiful island.*

After the Chinese Communists conquered mainland China in 1949, the Chinese Nationalist government moved to Taiwan. Generalissimo Chiang Kai-shek, the Nationalist president, made Taipei the capital of the Re-



Taiwan

public of China. The Nationalist government also controls several islands in the Taiwan Strait, which separates Taiwan and China. These islands include the Quemoy, Matsu, and the Pescadores groups. The Matsu and Quemoy groups are part of the Fujian province of mainland China, but are administered by Taiwan.

Government. The Chinese Nationalist government is based on a Constitution adopted in 1946 on the mainland. It provides for five branches of government—executive, legislative, judicial, control, and examination. Each branch is headed by a *yuan* (council).

The president is Taiwan's most powerful government official. The president is elected by the National Assembly to a 6-year term. The president appoints a prime minister to head the Executive Yuan. The National Assembly's chief functions are to elect the president and to amend the constitution. Most lawmaking is done by the Legislative Yuan.

After moving to Taiwan in 1949, the Nationalist government established a National Assembly and Legislative Yuan made up of members who had been elected on the mainland in 1947 and 1948. They were allowed to keep their seats indefinitely. They became known as "life-term" members. A 1990 judicial decision declared the system of "life-term" members unconstitutional. Under this decision, all remaining "life-term" members retired at the end of 1991. All members of the 405-seat National Assembly are now elected by Taiwan's voters to six-year terms. All members of the 161-seat Legislative Yuan are elected by the voters to three-year terms.

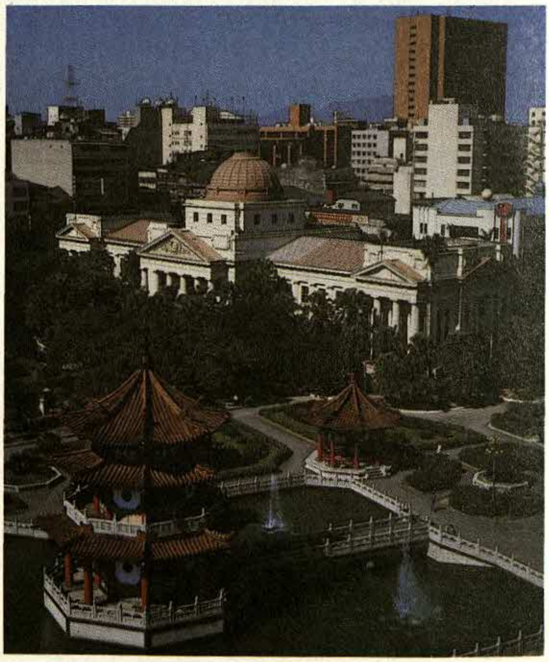
The Judicial Yuan is Taiwan's highest court. The Control Yuan reviews the activities of government officials and has the power of impeachment. The Examination Yuan gives tests for hiring and promoting government workers.

Although Taiwan is the seat of the Chinese Nationalist government, it is administered as a province of China. The president appoints a provincial governor who serves an indefinite term. The people elect the members of a provincial Assembly to four-year terms. The people also elect county and city government officials.

The Nationalist Party, or Kuomintang (KMT), is Taiwan's most influential political party. It has controlled the government in Taiwan since 1949. It was the country's only legal political party until 1989. The Democratic Progressive Party is the main opposition party.

People. Almost all the people of Taiwan live on the coastal plain that makes up the western third of the island. Most Taiwanese are Chinese whose ancestors came from Fujian (also spelled Fukien) and Guangdong (Kwangtung) provinces on the mainland. More than 1½ million more people fled to Taiwan after the Communist take-over in 1949. About 2 per cent of the population are non-Chinese native peoples related to Indonesians and Filipinos. Most of the native peoples, sometimes called *aborigines,* live on reservations in the mountains.

About a fifth of the people of Taiwan farm the land. Farms on the island average only 0.8 to 1.2 hectares in



Taipei is Taiwan's capital. Central Taipei includes a pleasant park and an art museum. A hotel tower, *background,* rises above modern office buildings.

A fertile valley near Taipei is the home of a farming community. About a fifth of the people of Taiwan farm the land. Most of the country is too mountainous for farming.

size, but Taiwanese farmers live well by Asian standards. Power tillers are gradually replacing water buffaloes in the fields. Many farmers can afford bicycles, motorcycles, refrigerators, radios, and television sets. Most of the farmhouses are made of brick, with tile roofs and central courtyards of packed earth or cement. A typical Taiwanese meal includes rice, served with vegetables and chopped meat or fish. Farmers and other people who work outdoors wear cone-shaped straw hats to protect them from the hot sun. Most city people in Taiwan wear Western-style clothing.

Facts in brief about Taiwan

Capital: Taipei.

Official language: Northern Chinese (Mandarin, or putonghua).

Area: 35,980 km², including the Pescadores islands, but excluding Matsu and Quemoy. *Greatest distances*—north-south, 378 km; east-west, 145 km. *Coastline*—893 km.

Elevation: *Highest*—Yü Shan (Mount Morrison), 3,997 m above sea level. *Lowest*—sea level.

Population: *Estimated 1996 population*—21,709,000; density, 592 people per km²; distribution, 75 per cent urban, 25 per cent rural. *1980 census*—17,968,797. *Estimated 2001 population*—22,772,000.

Chief products: *Agriculture*—asparagus, bananas, chickens and ducks, citrus fruit, mushrooms, pigs, pineapples, rice, sugar cane, sweet potatoes, tea, vegetables. *Fishing*—shrimp, snapper, tuna. *Forestry*—cedar, hemlock, oak. *Manufacturing*—calculators, clothing and textiles, iron and steel, paper, plastics, plywood, processed foods, radios, ships, sporting goods, sugar, television sets, toys.

Flag: The flag has a red field. A white sun appears on a blue canton in the upper left-hand corner. Red stands for liberty and sacrifice, and white for fraternity and honesty. Adopted in 1928. See **Flag** (picture: Flags of Asia and the Pacific).

Money: *Currency unit*—New Taiwan dollar or yuan. One dollar = 100 cents.

The Taiwanese speak various Chinese dialects. But almost all the people also use Northern Chinese (Mandarin), the official Chinese dialect. About half of the Taiwanese people practise a local traditional religion that blends Buddhism, Confucianism, and Taoism. About 42 per cent of the country's people are Buddhists, and about 8 per cent are Christians.

About 90 per cent of Taiwan's people can read and write. Children must attend primary school for six years and secondary school for three years.

Land and climate. Taiwan covers 36,000 square kilometres. This area includes the Pescadores but not the Matsu and Quemoy island groups.

Thickly forested mountains run from north to south and cover about half of Taiwan. The highest peak, Yü Shan (Mount Morrison), rises 3,997 metres above sea level. At many places along the eastern coast, the mountains drop sharply to the sea. Short, swift rivers have cut gorges through the mountains. In the west, the mountains slope to gently rolling hills and level land.

Taiwan has a subtropical climate, with hot, humid summers and an average annual rainfall of more than 250 centimetres. Temperatures average about 27 °C in summer and 18 °C in winter. Summer monsoons bring strong winds and rain. Winter monsoons bring rain and cooler weather to the north. Typhoons occur almost every year, with damaging rains and strong winds.

Economy. Taiwan has few natural resources except its mountain forests. Cedars, hemlocks, and oaks are the most valuable timber trees. Other forest products include bamboo, camphor, paper, and plywood. Taiwan's economy depends heavily on manufacturing and foreign trade. Factories produce calculators, cement, clothing and textiles, furniture, iron and steel, plastic goods, processed foods, ships, shoes, sporting equipment, sugar, televisions and radios, and toys. Many of these goods are exported, especially electronic products, clothing and textiles, plastic goods, plywood, and toys. Taiwan's chief trading partners are the United States, Japan, Hong Kong, and Germany.

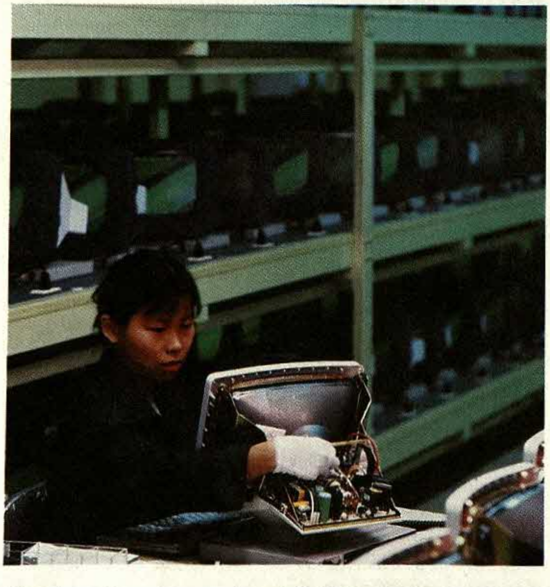
Only about a quarter of Taiwan's land can be farmed. The farmers have terraced many hills to provide more fields for growing rice. They use a lot of fertilizer and harvest two or three crops a year from the same field. The chief crops include asparagus, bananas, citrus fruit, maize, mushrooms, peanuts, pineapples, rice, sugar cane, sweet potatoes, tea, and vegetables. The farmers raise chickens, ducks, and pigs. Sea fishermen catch shrimp, snapper, and tuna. Carp, eels, and other fish are caught in inland ponds.

Coal is Taiwan's most important mineral, but there are only small deposits. Copper, gold, limestone, natural gas, petroleum, salt, silver, and sulphur are also mined.

Taiwan has a good network of roads, including a motorway that connects Taipei and Kaohsiung. The country has an average of about 1 car for every 30 people. Bus service is excellent. The government operates several railway lines. Kaohsiung and Chilung are the chief seaports. Taipei has a major international airport, and there are 8 other airports.

About 30 daily newspapers are published. Most families own a television set and one or more radios.

History. Aborigines were the first inhabitants of Taiwan. Some Chinese came to the island from the mainland as early as the 500's, but large settlements did not begin until the 1600's. Dutch traders occupied a Taiwanese port from 1624 until 1661. Koxinga, a Chinese Ming dynasty official, drove them out. Manchu conquerors had overthrown the Ming dynasty in mainland China, and Koxinga hoped to restore the dynasty to power. He wanted to use Taiwan as a base from which to attack the Manchus. But the Manchus conquered Taiwan in 1683 and it remained part of China for the next 212 years.



Manufacturing plays a major role in Taiwan's economy. The worker above is assembling a television set. Taiwan exports TV sets, radios, and many other manufactured products.

In 1895, Japan gained control of Taiwan as a result of the first Chinese-Japanese War. The Japanese developed Taiwan's agriculture and industry and expanded its transportation networks. China regained Taiwan after World War II ended in 1945.

In 1949, the Chinese Communists defeated Chiang Kai-shek's Nationalist forces and took control of the mainland. Chiang moved his government to Taiwan on Dec. 8, 1949.

After the Korean War began in 1950, the United States said it would protect Taiwan against possible attack from mainland China. Taiwan received about $1\frac{1}{2}$ billion U.S. dollars in U.S. economic and technical aid up to 1965. Though economically independent by then, Taiwan continued to receive U.S. military aid.

In 1971, the United States announced it favoured United Nations (UN) membership for Communist China. But the United States also said that Nationalist China—a charter member of the UN—should retain its UN seat. In October 1971, the UN expelled the Nationalists and admitted Communist China. In 1972, U.S. President Richard Nixon visited Communist China and agreed to the withdrawal of U.S. military forces from Taiwan.

During the 1970's, a number of nations ended their diplomatic relations with Taiwan and established ties with Communist China. The U.S. ended its diplomatic relations with Taiwan at the end of 1978, but agreed to continue to supply Taiwan with some military aid. Also, the two countries agreed to carry on unofficial relations through nongovernmental agencies. Trade between the two countries continues to thrive. About 40 per cent of Taiwan's exports go to the United States.

President Chiang Kai-shek died in 1975. Chiang's son Chiang Ching-kuo had become prime minister in 1972. He became the country's most powerful leader after his father died. He was elected president of Taiwan in 1978 and was reelected in 1984. Chiang died in 1988. Vice President Lee Teng-hui succeeded him as Taiwan's president.

In the late 1980's, relations between Taiwan and China began to improve. Taiwan allowed its citizens to visit China, and tensions between the two nations eased. Also in the 1980's, the government began political reforms that increased democracy in the country. In 1987, it ended *martial law,* which had been in effect since 1949. Under martial law, the military had some legal and political powers. Until 1989, the Nationalist Party had been the country's only legal political party. Opposition parties were legalized that year. Multiparty elections were held in 1991 for the National Assembly and in 1992 for the Legislative Yuan. The Nationalist Party won a majority of seats in both elections.

See also **Chiang Ching-kuo; Chiang Kai-shek; Chiang Soong Mei-ling; Pescadores; Quemoy; Taipei.**

Taj Mahal is one of the most beautiful and costly tombs in the world. The Indian ruler Shah Jahan ordered it built in memory of his favourite wife, Mumtaz Mahal, who died in 1629. The tomb stands near the city of Agra, in northern India, on the south bank of the Jumna River. About 20,000 workers were employed in its construction, completed after some 20 years by about 1650.

According to tradition, the Taj Mahal was designed by a Turkish architect. It is made of white marble and rests on a platform of red sandstone. At each corner of the platform stands a slender *minaret* (prayer tower). Each tower is 40.5 metres high. The building itself is almost 57 metres square. A dome covers the centre of the building. It is over 21 metres in diameter and 36.5 metres high. Passages from the Muslim holy book, the *Quran,* decorate the outside along with inlaid floral patterns. A central room contains two *cenotaphs* (monuments). Visitors can see the monuments through a carved alabaster screen. The bodies of Shah Jahan and his wife lie in a vault below. The tomb stands in a garden.

See also **Asia** (picture); **India** (picture).

Tajikistan, also spelled *Tadzhikistan,* is a mountainous country in central Asia. It became independent in 1991, after more than 60 years as a republic of the Soviet Union. The country's name in Tajik, the official language, is Jumhurii Tojikiston (Republic of Tajikistan).

Tajikistan covers 143,100 square kilometres. Tajikistan's capital and largest city is Dushanbe.

Government. Tajikistan is a republic. The head of state is the chairman of parliament, who is elected by members of parliament. The chairman appoints a prime minister, who heads a cabinet called the Council of Ministers. The cabinet helps carry out the functions of the government. The chairman also appoints council members. A parliament elected by the people makes Tajikistan's laws. The main units of local government are regions and cities.

Tajikistan's highest court is the Supreme Court. There are also regional courts and local courts. All judges are elected to five-year terms.

People. For Tajikistan's total population, see the *Facts in brief* table with this article. About 62 per cent of Tajikistan's people are ethnic Tajiks. Uzbeks make up about 23 per cent of the population, and Russians account for about 9 per cent. Other ethnic groups include Tatars, Kazakhs, Turkmens, and Kyrgyz people.

Most Tajiks are Sunni Muslims. Groups of Shiite Muslims live in remote mountain areas. In addition, small communities of a sect called the Ismaili Khoja Muslims live in the Pamirs, a mountain range in southeastern Tajikistan.

Facts in brief about Tajikistan

Capital: Dushanbe.

Official language: Tajik.

Area: 143,100 km². Greatest distances—north-south, 485 km; east-west, 685 km.

Elevation: *Highest*—Communism Peak, 7,495 m. *Lowest*—Syr Darya river at northwestern border, 300 m.

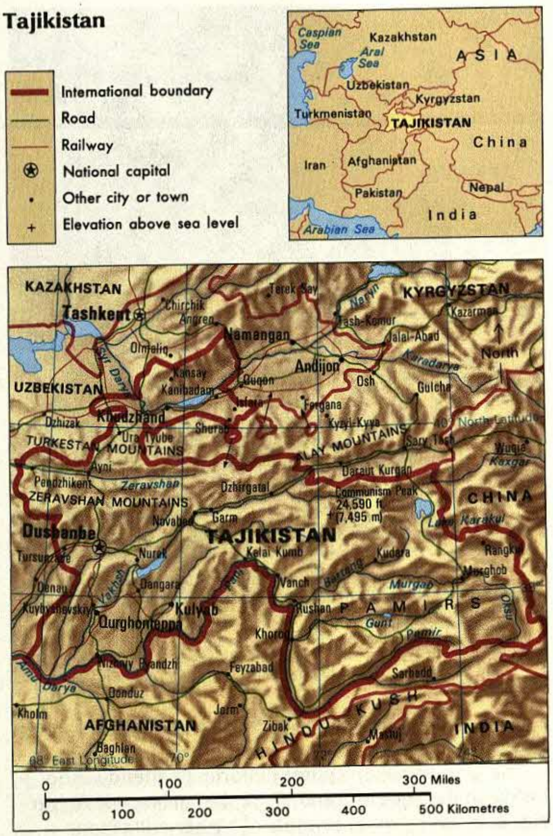
Population: *Estimated 1996 population*—6,155,000; density, 41 people per km²; distribution, 67 per cent rural, 33 per cent urban. *1989 census*—5,112,000. *Estimated 2001 population*—6,964,000.

Chief products: *Agriculture*—cotton, fruit, grain, livestock, vegetables. *Manufacturing*—food processing, textiles, wine. *Mining*—antimony, coal, fluorite, lead, molybdenum, natural gas, petroleum, salt, tungsten, uranium, zinc.

Flag: The flag has horizontal stripes of reddish orange, white, and green. An emblem lies in the centre of the middle white stripe. It consists of an arc of seven yellow, five-pointed stars over a yellow figure resembling a crown. See **Flag** (picture: Flags of Asia and the Pacific).

Money: *Currency unit*—rouble. One rouble = 100 kopecks.

Tajikistan



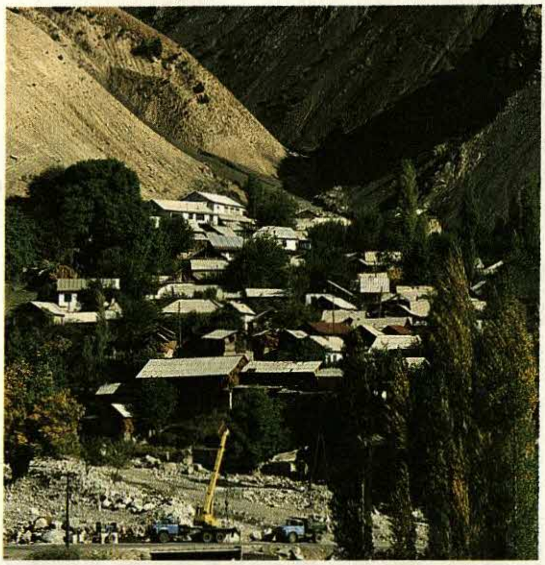
Under Soviet rule, religious activity was severely restricted. The government closed many mosques, prohibited religious services outside officially recognized places of worship, and tried to discourage religion through propaganda and education. But religious feeling remained strong among Tajiks. Islamic leaders held secret prayer meetings, gave sermons, and practised religious rituals despite Soviet restrictions.

About two-thirds of Tajikistan's people live in rural areas. The most heavily settled regions of the country are along rivers and oases. Most people live in rural villages made up of sun-dried earthen houses surrounded by earthen walls. City dwellers live in single-storey houses and multistorey apartment buildings.

Most families in Tajikistan are large. Many members of an extended family may live together in one household. Such a household might include parents, married children and their offspring, and other relatives. Because of marriage patterns, it is common for all people in a village to be related. Some Tajiks follow a Muslim custom that permits a man to have as many as four wives.

Tajiks wear both Western-style and traditional clothing. Traditional garments include loose cotton trousers and a dark or multicoloured robe for men and colourful, embroidered silk dresses for women. Both men and women wear embroidered skullcaps.

Traditional Tajik foods include a rice dish called *pilaf* and *shashlik* (lamb or beef grilled on skewers). Green tea is the most popular drink.



A mountain village in Tajikistan lies nestled in a narrow valley. Mountains cover more than 90 per cent of Tajikistan. Many Tajiks live in valleys near rivers or oases.

Tajik is an Iranian language. It is much like Farsi, the chief language of Iran.

The government requires children to attend school between the ages of 6 and 17. Tajikistan has one university and several other schools of higher education.

Land and climate. Over 90 per cent of Tajikistan is mountainous, and over half lies above 3,050 metres. The highest peaks are snow-covered all year. The Pamirs rise in the southeast. The Alay and Tian Shan mountain ranges stretch across much of the rest of the country. Fedchenko Glacier, one of the world's longest glaciers, extends 77 kilometres in the Pamirs. Two major rivers, the Amu Darya and the Syr Darya, cross Tajikistan. Other rivers include the Vakhsh, Kafirnigan, and Zeravshan. Earthquakes often occur throughout the region.

Summers in the valleys are typically long, hot, and dry. Winters in the highlands are long and cold. Temperatures in the valleys average 2 °C in January and 30 °C in July. Temperatures in the highlands average −20 °C in January and 22 °C in July. In parts of the eastern Pamirs, temperatures can drop to −50 °C. Tajikistan receives annual rainfall of less than 20 centimetres.

Economy. Agriculture accounts for about two-fifths of the value of Tajikistan's economic production. Cotton is Tajikistan's chief agricultural product. Other crops include various fruit, grains, and vegetables. Farmers also raise a variety of livestock, including cattle, chickens, horses, Karakul sheep, and yaks. Chief agricultural areas lie in the country's southwest and north.

Tajikistan's industries, which include food processing, hydroelectric power generation, mining, and textile manufacturing, account for about a third of the value of the country's economic production. Chief industrial centres are the cities of Dushanbe and Khudzhand. The mines of the region yield a variety of minerals, including antimony, coal, fluorite, lead, molybdenum, salt, tungsten, uranium, and zinc. The huge Nurek Dam on the Vakhsh River provides hydroelectric power for industries and water for irrigation projects.

Tajikistan has a limited highway and railway system. Heavy snows close roads in the Pamirs at least half the year. The airport in Dushanbe handles all flights.

A radio and a television station broadcast from Dushanbe in several languages. The country also publishes newspapers and magazines in several languages.

History. People have inhabited the area that is now Tajikistan for thousands of years. Persians of the Achaemenid Empire settled in the region as early as the 500's B.C. These Persians became the ancestors of the Tajiks. They ruled the region until Alexander the Great gained control of their empire in 331 B.C. After Alexander's death in 323 B.C., the region split into a number of independent states. Part of Tajikistan was absorbed by the Seleucids, who ruled until about 250 B.C. Another part came under the control of the Bactrian State, which ruled until about 130 B.C. At that time, nomadic tribes from western China invaded the region. They were overthrown by the Kushans by the A.D. 100's. Sassanians from Persia and White Huns from Central Asia defeated the Kushans by the 400's.

Turkic tribes began moving into Central Asia in about the 500's. Arab armies swept into the region in the mid-600's and introduced Islam. Various Turkic peoples from eastern Persia and central Asia ruled what is now Tajikistan from about 900 to 1200. Mongols led by Genghis Khan conquered the region in the 1200's. Turkic tribes called Uzbeks ruled from the 1500's to the 1800's.

In the late 1800's, czarist Russian forces conquered part of the region. In 1917, Communists took control of Russia. By 1921, Russians controlled all of what is now Tajikistan. In 1922, the Soviet Union was formed under Russia's leadership. A rebel group of nationalist Muslim Tajiks known as the *Basmachis* resisted Soviet control into the mid-1920's. In 1924, the Tajik Autonomous Soviet Socialist Republic was formed within the Uzbek Soviet Socialist Republic. In 1929, it acquired additional territory inhabited mostly by Uzbeks and became the Tajik Soviet Socialist Republic.

The Soviets made many changes in Tajikistan. The Soviet government built roads, railways, schools, and modern housing. It also developed industries, especially agriculture and mining. In addition, the Soviets *collectivized* agriculture—that is, they transferred control of farms and livestock to the government. They also tried to reduce the influence of Islam and prohibited the Tajiks from practising many of their traditions. The government maintained strict control of all aspects of Tajik life until the late 1980's. At that time, the government made reforms that gave people more freedom.

In the 1980's, opposition groups began to demonstrate against the Communist-controlled government, demanding better housing and more control over their own affairs. In 1989, Tajik replaced Russian as the official language of the republic. Then, in 1990, Tajikistan declared that its laws overruled Soviet laws. In 1991, the government introduced a free-enterprise system and began to sell off businesses to private owners. In September 1991, Tajikistan declared its independence. After the collapse of the Soviet Union in December, the country joined a loose association of former Soviet republics called the Commonwealth of Independent States.

In September 1992, anti-Communist and Islamic opposition groups forced the resignation of President Rakhman Nabiyev, a former Soviet Communist Party chief. In November, opposition groups were forced out of power by supporters of the former government, most of whose leaders were former Communist officials. The parliament eliminated the office of president and made the chairman of the parliament the head of state. Unrest continued in Tajikistan.

See also **Commonwealth of Independent States; Dushanbe.**

Tajo River. See **Tagus River.**

Takahe is a flightless bird that lives only in New Zealand. Takahes have deep blue and olive green plumage, and thick red bills and legs. They eat seeds and the soft stems of plants. They make grass nests on the ground and line them with leaves. For more than 50 years, ornithologists believed that takahes were extinct. But in 1948, takahes were rediscovered in the South Island of New Zealand. They are extremely rare.

Scientific classification. The takahe belongs to the family Rallidae. It is *Porphyrio mantelli.*

Takdir Alisjahbana, Sutan (1908-1994), an Indonesian writer and philosopher, became known for his pioneering studies of the Indonesian language and its literature. He became *rektor* (president) of the Indonesian National University in Jakarta in 1968.

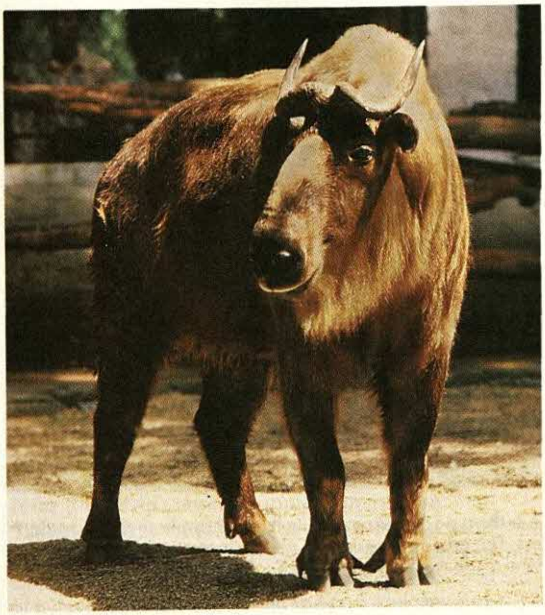
Takdir Alisjahbana was born in Sumatra. He was able to attend a Dutch school. He had his first novel published in 1929. He became a school teacher, but only for a year. In 1930, he moved to Jakarta and found employment with the *Balai Pustaka,* the government literary institute. In 1933, he became one of the founding editors of *Pudjangga Baru,* a most influential literary magazine in Indonesia.

In 1937, Takdir Alisjahbana began his studies at the School of Law in Jakarta. He took his law degree in 1942. After the Japanese occupied Indonesia in 1942, Takdir became head of the language office and worked on the development of the Indonesian language. This development was necessary because the Japanese forbade the use of Dutch, and at first few Indonesians knew Japanese. After the Japanese surrender in 1945, Takdir became involved in the Indonesian Socialist Party. From 1945 to 1960, he was a member of various legislative councils and committees. From 1958, he travelled and extended his education in Europe, particularly in Germany. From 1959 until 1962, he lived in the United States.

He was unwilling to return to Indonesia under President Sukarno. In 1963, he became professor in the University of Malaya in Kuala Lumpur. At that time, during the confrontation between Indonesia and Malaysia, the Indonesian government branded him a traitor. They seized his property in Indonesia. In 1968, after the fall of President Sukarno, he returned to Indonesia to live.

Takdir Alisjahbana wrote many books and articles, including works on philosophy, culture, language, literature, and history. He was appointed to posts in many Indonesian and international organizations.

See also **Indonesia** (History).



The takin is a large hoofed mammal that resembles a musk ox. The animal lives in Burma, the Himalaya, and parts of China.

Takin is a large hoofed mammal closely related to goats, sheep, and musk oxen. Takins live in central, western, and southwestern China, in Burma, and in the Himalaya. They inhabit dense bamboo forests and thickets of rhododendrons on steep, rugged slopes.

Takins resemble musk oxen, with stout forelegs, a large head, and a thick neck. They have shaggy fur that ranges from blackish-brown to golden or yellowish-white. A dark stripe runs along the middle of the back. Both males and females grow horns, but the females' horns are smaller. Takins measure up to about 110 centimetres tall at the shoulder and weigh up to 350 kilograms. Males are heavier than females.

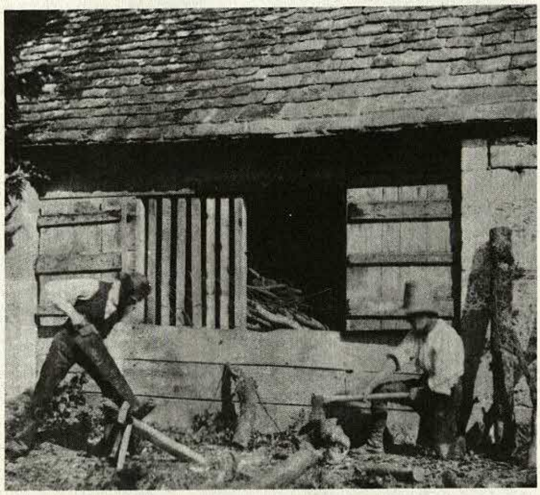
Takins are active mostly at dusk and dawn, but they may be active throughout the day in foggy or cloudy weather. Normally, they spend the daylight hours hidden in dense vegetation. During the warm months, takins feed primarily on young trees, grass, and tender herbs. In winter, they eat mostly the tips of bamboo stems and willow branches.

During the summer, takins gather in large herds led by an old *bull* (male). In winter, the herds are smaller and move down into the valleys. Takins mate in July or August. The *cow* (female) gives birth to a single young, called a *kid,* in March or April.

Scientific classification. The takin belongs to the bovid family, Bovidae. It is *Budorcas taxicolor.*

Taklimakan Desert lies in northwestern China between the Tian Shan and Kunlun mountains. Its small hills, rising to a maximum altitude of 1,500 metres, and shifting sand dunes cover an area of about 323,700 square kilometres in the Xinjiang region. For location, see **China** (physical map).

Talbotype is a picture made by an early photographic process. The name honours its inventor, W. H. Fox Talbot, an English scientist. He first described the process in 1839. He made a sheet of paper sensitive to light by putting it in a series of baths of sodium-chloride and sil-



A talbotype is a picture made by an early photographic process. The process was named after its inventor, W. H. Fox Talbot, who made this talbotype, called *Wood Sawers,* around 1845.

ver-nitrate solutions. Then he exposed the paper to light in a camera or to sunlight. The silver salts formed a negative image, turning dark where light fell upon them. After he treated this master negative with salt solution, he could print an endless number of paper positives.

In 1841, Fox Talbot increased the sensitivity of the paper by developing it in gallo-nitrate of silver and treating it in sodium thiosulphate. He called the new process *calotype.* Later, he called it *talbotype.* Fox Talbot's work, however, did not make such a clear picture as the daguerreotype (see **Daguerreotype**). The talbotype process was the first negative-positive process. After 1851, the wet-collodion technique, which used glass for negative material, replaced the talbotype process.

Talc (chemical formula, $Mg_3Si_4O_{10}(OH)_2$) is a soft mineral found in flat smooth layers of rock, and in compact masses. It is so soft that it can be scratched with the fingernail, and it feels soapy or greasy. Talc is translucent, which means that it will allow light to go through, yet is not transparent. Talc is white, greenish, or dark grey. *Steatite* (soapstone) is a compact talc. It was used as a material for carving in ancient Egypt and China.

Talc has many commercial uses. It is sold in slabs or in powdered form. Slabs are used to line furnaces and heating stoves, and for electric insulation, because talc is a poor conductor of heat and electricity. It is ground up to make talcum powder. Powdered talc is also used in crayons, paint, paper, and soap.

The leading talc-producing nations include Finland, Japan, and the United States.

See also **Hardness; Soapstone; Mineral** (picture: Common minerals with nonmetallic lustre).

Talent is a famous old unit of weight and value. The Hebrews, Babylonians, Greeks, and Romans used it. No coin of this denomination was ever *struck* (made), because such a coin would be too large. Instead, a certain number of other coins equalled a talent. The Hebrew silver talent equalled 3,000 shekels in silver. The gold talent had different weights and values in different places. The present use of the word *talent,* meaning *special ability,* may come symbolically from a Bible story (Matthew 25: 14-30).

Talipes. See **Clubfoot.**

Talking book. See **Handicapped** (Special education); **Library** (Services for special groups).

Tallchief, Maria (1925-), became the first American-trained ballerina of international importance. She was known especially for her technical brilliance. Tallchief danced with the Ballet Russe de Monte Carlo from 1942 to 1947, but her career was chiefly associated with the New York City Ballet. She danced with this company from 1947 to 1965.

Tallchief was born in Fairfax, Oklahoma, U.S.A., the daughter of an Osage Indian father and a Scottish-Irish-Dutch mother. She was married to New York City Ballet director George Balanchine from 1946 to 1951. She created roles in many of his ballets, including *Orpheus* (1948) and *Scotch Symphony* (1952). Her dancing in Balanchine's version of *Firebird* (1949) established her international reputation. Tallchief founded the Chicago City Ballet in 1980 and served as its artistic director from 1980 to 1987.

Maria Tallchief danced the title role in *The Firebird, above,* with American ballet dancer Francisco Moncion.

Talleyrand (1754-1838) was a French statesman famous for his diplomatic achievements under Napoleon I and at the Congress of Vienna. His full name was Charles Maurice de Talleyrand-Périgord, Prince de Bénévent. He was born in Paris. A childhood accident made him lame, and he was educated for a religious career. He became a priest in 1775. In 1789, he was named bishop of Autun, a high post in the church.

Supports state above church. Talleyrand was elected in 1789 to the States-General, the French parliament. He became a moderate leader of the French Revolution. He favoured constitutional monarchy and signed the Declaration of the Rights of Man and of the Citizen. He was elected president of the National Assembly in 1790. Talleyrand won popularity for proposing that the government take church property to pay its debts. The

Pope excommunicated him in 1791 for his part in giving control of the French Catholic Church to the state, and for taking an oath to the constitution.

Talleyrand was in England on a diplomatic mission when the Revolution took a radical turn in 1792, and he was exiled as a royalist sympathizer. After two years in England, he fled to America.

Joins Napoleon. Talleyrand was allowed to return to France in 1796. Through the influence of Madame de Staël, one of his friends, Talleyrand was made minister of foreign affairs. While serving his nation, he decided to rebuild his fortune. In the famous XYZ Affair in 1797, he was accused of demanding bribes of the United States representatives (see **XYZ Affair**).

Talleyrand also decided to build his political future by attaching himself to Napoleon. He helped Napoleon replace the Directory, first with the Consulate in 1799, and then with the Empire in 1804. As Napoleon's adviser and foreign minister, he conducted delicate negotiations such as those that produced the Peace of Tilsit with Russia in 1807. See **Napoleon I.**

Deserts Napoleon. Napoleon depended on Talleyrand, but distrusted him. Talleyrand came to oppose Napoleon's conquests as injurious to France and to European peace. After 1807, Talleyrand resigned from office and became the centre of the growing opposition to the emperor. His leadership was decisive in securing Napoleon's abdication and the restoration of the Bourbon kings in 1814. His diplomatic skill at the Congress of Vienna of 1814 and 1815 gave defeated France a powerful voice there (see **Vienna, Congress of**).

His last years. After 1815, the Bourbon court excluded Talleyrand from public affairs. But in 1830, when the Bourbons lost public confidence, Talleyrand helped steer a revolution toward constitutional monarchy under Louis Philippe. He became ambassador to Great Britain, where he guided negotiations that made Belgium independent, and brought France and Britain into alliance.

See also **French Revolution.**

Tallinn (pop. 458,000) is the capital and largest city of Estonia. It lies on the northern coast of Estonia, along the Gulf of Finland. For the location of Tallinn, see **Estonia** (map).

Tallinn is an important industrial and cultural centre and seaport. Its products include industrial machinery, paper, and textiles. The city is best known for its many beautiful churches, castles, and other buildings that were erected from the 1200's to the 1500's.

Tallinn existed before the mid-1100's, but its founding date is unknown. It was the capital of the independent nation of Estonia from 1918 to 1940. In 1940, the Soviets seized Estonia and forced it to become part of the Soviet Union. In 1991, the Soviet Union collapsed and Estonia became an independent nation again.

Tallis, Thomas (1505?-1585), was an English composer of religious vocal music during the Renaissance period. Tallis' earlier music was written for the Roman Catholic Church. It was complicated, with many interweaving voices known as *counterpoint,* and used Latin words. Later, under the Protestant Queen Elizabeth I, Tallis composed *anthems* (choral pieces with English words). His late music is less elaborate and more expressive. *Spem in alium,* a spectacular unaccompanied choral work called a *motet,* is often performed by choruses today.

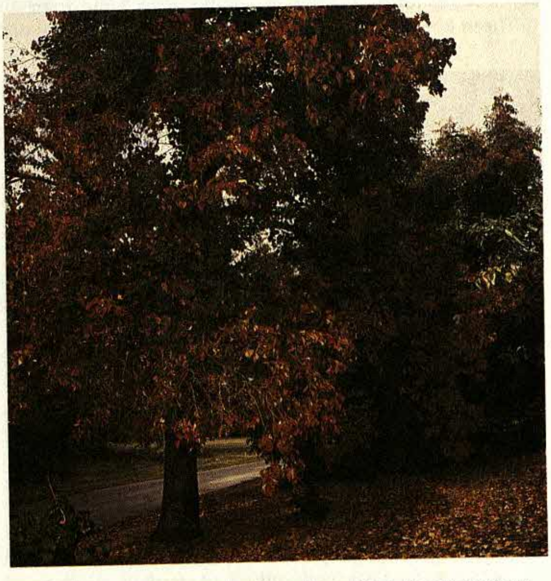
Tallow is a fatty substance used in many products. It is obtained by *rendering* (melting) the fat of cattle, goats, or sheep. Tallow is classified as either *edible* or *inedible.* Edible tallow is used primarily as an ingredient in shortening for cooking and baking. Most inedible tallow is used to make animal feed, such as cattle feed and pet food, and candles. In addition, inedible tallow is treated with chemicals to make bar soap, soap flakes, and detergents (see **Detergent and soap** [How detergents are made]). Edible tallow is white and almost tasteless. Inedible tallow may be white, yellow, or brown.

Tallow is an important source of certain fatty acids that are used to make hundreds of everyday products. These products include car tyres, cosmetics, detergents, lubricants, and plastics. Fatty acids from tallow can be used instead of the chemicals that are ordinarily manufactured from petroleum. Thus, tallow can help conserve the world's limited supply of petroleum.

Tallowtree is the name of several trees that produce a waxy substance that can be used like tallow for making candles. Today, mineral waxes usually are used instead of tallow in candle making. In the past, the tree most often used for its tallow was the *Chinese tallowtree.* The seeds of this tree hang on waxlike threads among the leaves. Workers crushed and boiled the capsules and seeds and skimmed off the tallow as it rose to the surface. The tallow was then melted and refined.

The Chinese tallowtree has been planted as a shade tree and along streets in the Southeastern United States for more than 100 years. It now grows wild in areas along the Atlantic and Gulf coasts. Its leaves flutter in the slightest breeze and give it the appearance of a poplar. The leaves turn brilliant red in autumn.

Scientific classification. Tallowtrees belong to the spurge family, Euphorbiaceae. The Chinese tallowtree is *Sapium sebiferum.*



The Chinese tallowtree is planted as a shade tree in regions that have mild winters. Its leaves turn brilliant red in autumn.

Talmud is a collection of Jewish religious and civil laws, together with scholarly interpretations of their meaning. The Talmud ranks second to the Bible as the most sacred and influential written work of the Jewish religion. Judaism considers the full-time study of the Talmud to be one of the most honourable occupations.

The Talmud consists of two parts, the *Mishnah* and the *Gemara.* The Mishnah is the written version of traditional Jewish oral law. Short passages of the Mishnah are followed by extremely thorough explanations, which make up the Gemara. The scholars who wrote the Gemara did not always agree in their interpretations of the Mishnah. As a result, the Gemara includes many debates on small details of Jewish law. It also discusses history and Jewish customs and includes Jewish folk tales.

The Talmud consists of 63 sections called *tractates,* which are divided into six *orders.* Each order deals with a different subject. For example, the order *Nashim* (Women) discusses marriage, divorce, and other matters that concern relationships between a man and a woman. Other orders cover such subjects as cleanliness, religious feasts, and civil and criminal law.

According to Jewish tradition, the Mishnah originated in the time of Moses during the 1200's B.C. and was memorized and handed down from generation to generation. Its contents were collected and written down from about A.D. 70 to 200. The Gemara, which has two versions, was written between about 200 and 500. The *Palestinian Gemara* was completed in about 425 and was first printed in the 1520's, in Venice, Italy. The *Babylonian Gemara* was completed in about 500 and was first printed in the early 1480's, in Spain.

See also **Akiva Baer ben Joseph.**

Tamales. See **Mexico** (Food).

Tamarin is a type of small monkey that lives in tropical rainforests in Central and South America. The tamarin is closely related to, but slightly larger than, the marmoset (see **Marmoset**). Tamarins grow up to about 30 centimetres long, not including the tail, which may be up to 45 centimetres long. The animals weigh up to 1 kilogram.

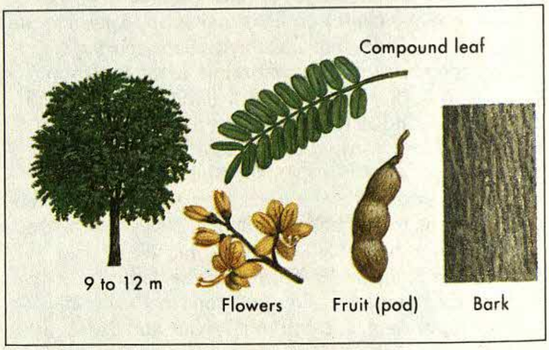
There are 14 *species* (kinds) of tamarins. Most are multicoloured, with red, white, and brown the most common colours. Some species have long hair on the top of the head and showy moustaches. The *lion tamarins* of eastern Brazil have a mane of long, silky hair on the head and a bright golden-orange colouring. Lion tamarins are in danger of extinction. The growth of urban areas and spreading deforestation has destroyed much of their habitat.

Lion tamarins have long, golden-orange hair. These small monkeys are found in tropical rainforests of eastern Brazil.

Tamarins eat fruit, insects, frogs, and tree gums. They live in groups of up to 40 members and communicate with each other by using a wide variety of high-pitched calls. Infant tamarins cling to the backs of their parents or other family members.

Scientific classification. Tamarins belong to the tamarin and marmoset family, Callitrichidae. Lion tamarins are genus *Leontopithecus.* Other tamarins are genus *Saguinus.*

Tamarind is an attractive evergreen tree that grows in the tropics. It may grow 23 metres high. The tamarind develops small pale green leaves and tiny yellow flowers. Pods about 8 to 10 centimetres long contain the seeds of the tree. These pods contain an acid brown pulp used to prepare refreshing drinks. In India and Arabia, the pulp is pressed into cakes and sold as a delicacy. Ornamental tamarinds are grown in warm parts of the world.



The tamarind has compound leaves and tiny flowers. The pods contain an acid pulp used to make cakes and drinks.

Scientific classification. The tamarind belongs to the pea family, Leguminosae (Fabaceae). It is *Tamarindus indica.*

Tamarisk is a small tree or shrub which grows on salty ground. There are about 100 different kinds of tamarisk. Most species are found in marshes and near coasts around the Mediterranean Sea and in the Middle East. Tamarisks grow to about 2 metres tall. Their leaves are small and scalelike, and they usually produce small pink flowers in spring. Some cultivated varieties have deep red-coloured flowers. Tamarisk trees should be pruned back after flowering to encourage a compact, bushy growth.

Tamarisk trees are planted as windbreaks in coastal areas. In North Africa, Bedouins collect manna, a sweet substance from the stems of tamarisk trees. The manna is produced by scale insects sucking the tree sap. The insect galls on tamarisk trees are used to dye leather and wool in Africa and India (see **Gall**).

Scientific classification. Tamarisks make up the family Tamaricaceae.

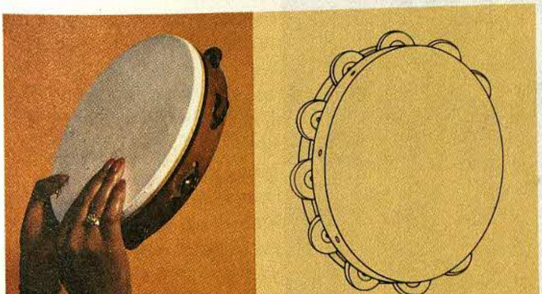
Tamayo, Rufino (1899-1991), was an important Mexican painter. He became noted for his bold, brightly coloured paintings of human figures, animals, and still lifes. Tamayo painted in a semiabstract style, in which he distorted forms to make them more expressive. His paintings reflect the influence of the folklore, history, and landscape of Mexico. But unlike other major Mexican artists of his day, Tamayo seldom emphasized nationalism or political ideology.

Tamayo was born in Oaxaca, Mexico. In the early 1920's, he worked sketching ancient Indian sculpture for the National Museum of Anthropology in Mexico City. In the 1930's and early 1940's, his style was affected by his exposure to the works of the modern European painters Georges Braque, Joan Miró, and Pablo Picasso. Beginning about 1970, Tamayo's paintings became more abstract and philosophical, often exploring the individual's relation to the universe.

Tambo, Oliver (1917-1993), led the African National Congress (ANC) in exile after it was banned in South Africa in 1960. See **African National Congress.**

Oliver Reginald Tambo was born into a peasant family at Bizana, in Pondoland, Transkei, South Africa. Tambo graduated with a Bachelor of Science degree from Fort Hare University in 1941. In 1952, he set up a legal practice in partnership with Nelson Mandela (see **Mandela, Nelson**). Tambo and Mandela were also founder members of the ANC Youth League in 1943. Tambo was elected to the ANC executive in 1949. Despite being under a government banning order from 1954, he served as general secretary of the ANC from 1955 to 1958, and as deputy president general from 1958. After the ANC was banned in 1960, Tambo left South Africa. He returned from exile in 1990, and was leader of the ANC until Nelson Mandela was elected as president of the ANC in 1991.

Tambourine is a percussion instrument that consists of a narrow wooden or metal hoop with a thin *membrane* (sheet) of plastic or animal skin stretched across one side. All tambourines have small metal discs attached to the hoop. Performers hold the tambourine in one hand. They play it by striking it with the other hand, by hitting it against the knee or upper leg, and by shaking it. The tambourine was made popular by Turkish soldiers called *Janissaries,* who played the instrument in military bands from the 1400's to the early 1800's. Western musicians began using the tambourine during the 1700's. See also **Music** (Percussion instruments).



The tambourine is a hoop that has metal discs on the rim and a thin membrane stretched across one side. It can be played by shaking or striking.

Tamerlane (1336?-1405) was an Asian conqueror who created by the sword a vast but short-lived empire. Tamerlane was also referred to as Timur the Lame.

Tamerlane was a Tatar, a Mongol Turk descended from Genghis Khan, another Asian conqueror. He was born of a chief's family near Samarkand in Turkestan. He was a well-educated, devout Muslim. After 1358, he engaged in numerous wars. Tamerlane mounted the throne at Samarkand in 1369, and ruled an extensive central Asian kingdom. After 1369, his armies struck west and south into Afghanistan, Persia, India, and Asia Minor.

Tamerlane invaded India in 1398, sacked Delhi, and massacred most of its inhabitants. In 1401, he turned to Syria. He captured Baghdad, and in 1402 he completely destroyed the Turkish army that had been sent against him. He then captured Damascus and defeated Egyptian armies. Tamerlane was now the ruler of a vast empire with its heart in Turkestan. He next moved to conquer China. But before he could reach his objective, he died of fever in his camp. His empire soon fell apart.

Tameside (pop. 211,700) is a local government district in Greater Manchester, England. Ashton-under-Lyne is the district's administrative centre. Many industries are located in Tameside, including clothing, computer services, engineering, food processing, pharmaceuticals, and textiles. Service industries, particularly warehousing and distribution, employ many workers. The district's name comes from the River Tame, which runs through it. See also **Manchester, Greater.**

Tamil Nadu is a state in southeast India. One of the four Dravidian states of India, it has had more than 2,000 years of continuous cultural history (see **Dravidians**). Tamil is one of the oldest literary languages in India. Tamil Nadu has some of the most remarkable temple architecture in India, and a living tradition of music and dance. People who live in the state are called Tamilians. Madras is the capital city.

People and government

People. There are isolated groups of tribal peoples, such as the Todas who live in the Nilgiri Hills. The great majority of Tamil Nadu's inhabitants are Dravidians. More than 85 per cent of the population speak Tamil, the main language of the state. In the north, especially around Madras, many people speak Telugu, another Dravidian language. They make up 10 per cent of the population.

The vast majority of the people of Tamil Nadu are Hindus. More than 5 per cent are Christians, especially in the south where Roman Catholic and Protestant missions have been active for over 500 years. Christianity in the south may date from A.D. 52, when many people believe St. Thomas the Apostle came to India and was martyred in Mylapore (now a suburb of Madras). There are also small groups of Jains, Muslims, and Parsees.

Government. Tamil Nadu took its present form as a result of the States Reorganization Act of 1956. By that time, the earlier British presidency of Madras had lost its northern districts to Andhra Pradesh and its western districts to Mysore, now Karnataka. Under the 1956 Act,

Facts in brief about Tamil Nadu

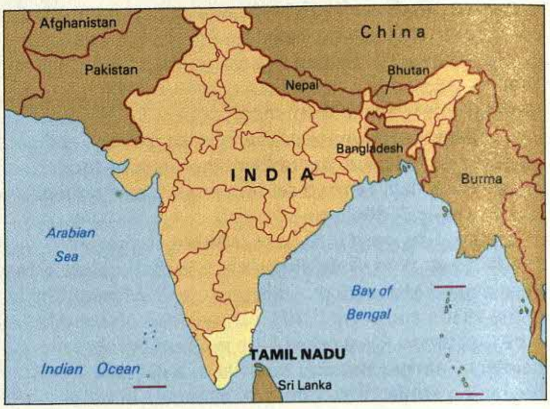
Population: *1991 census*—55,638,318.
Area: 130,058 km².
Capital city: Madras.
Largest cities: Madras, Madurai, Coimbatore, Salem, Tiruchirappalli.
Chief products: *Agriculture*—cotton, peanuts, rice, sugar. *Manufacturing*—engineering, motor vehicles, steel, textiles.

it also lost the district of Malabar but gained four *talukas* (subdivisions) from Trivandrum and another, Shencottah taluka of Quilon District, when the new state of Kerala was formed. Tamil Nadu now has 22 administrative districts.

Tamil Nadu has 39 elected members in the *Lok Sabha* (lower house) and 18 members of the *Rajya Sabha* (upper house) of the Indian parliament. It elects 234 members to its own Legislative Assembly and 63 to its Legislative Council. Until 1967, the Indian National Congress dominated the Assembly. But after an attempt by the central government to impose Hindi as a national language, the Congress Party was routed by a regional party, the *Dravida Munnetra Kazhagam* (the DMK). Since then, either the DMK or a splinter party, the All India Anna DMK, has been in power in the state.

Economy

Agriculture. Nearly three-quarters of the population of Tamil Nadu still depend on agriculture, although it only contributes one-third of the state's economic wealth. Farmers have used irrigation in the region for more than 2,000 years. They built *tanks* (large, shallow reservoirs) as early as A.D. 800 in the areas around Madras. Further south, the people have used the Kaveri River for irrigation for over 1,000 years. There are more than 20,000 kilometres of *anicuts* (irrigation channels) in Tamil Nadu. In both regions, rice is the most important crop. Tamil Nadu grows more than 10 per cent of India's rice.



Tamil Nadu lies in the far southeast of India. It is the closest state to the island of Sri Lanka.

Sugar cane, peanuts, and other oilseeds are important cash crops. Bananas, cotton, millet, and rubber are also grown. Tea and coffee from the hills of the Western Ghats make a major contribution to exports and domestic consumption. The hills are also famous for the production of cardamom, ginger, pepper, and other spices. Potatoes are widely grown in the Nilgiris for sale in India's big cities.

Manufacturing. Tamil Nadu is one of India's most industrialized states. Cotton processing began in mills in Madras city during the 1800's. Today, cotton textile production is a major industry. In the 1930's, the government developed hydroelectric power in the hills of the southwest, and Coimbatore rapidly became a major industrial centre for the textile industry. Tamil Nadu has since become an engineering centre, producing a range of products that includes cars, buses, lorries, motor cycles, precision tools, and railway rolling stock. The state also has cement, fertilizer, sugar, and oil refining industries. Tamil Nadu's more traditional industries remain important. Leather especially is one of India's major exports.

Tea plants grow in the Nilgiri Hills, part of the Western Ghats. Tea is grown for export, as well as for domestic consumption.

Mining. Tamil Nadu has extensive mineral deposits, including bauxite, gypsum, and limestone. *Lignite* (brown coal) is mined at Neyveli. Salem steel mill processes iron ore. Magnesite is mined in Salem district.

Transportation. Tamil Nadu has some of the best road and rail connections in India. Madras is the focus for the transport system, linking the state with other major centres in India and abroad. The broad-gauge rail system links Madras with Bangalore, Cochin, Bombay, Delhi, Calcutta, and other northern destinations. A narrow-gauge rail system serves the south. Tamil Nadu also has a very large number of roads. As well as the national highways, there is a widespread network of good state highways.

Communications. Daily newspaper circulation runs at 28 copies per 1,000 people, the fifth greatest in India. In the mid-1980's, over 85 per cent of the population had access to television, and nearly 100 per cent to radios. Nearly two-thirds of the people can read and write.

Land

Location and description. Tamil Nadu is located in southeastern India. To the east and south is the Bay of Bengal and the Indian Ocean. Across the Palk Strait in the southeast lies the island country of Sri Lanka. To the north and west are the Indian states of Andhra Pradesh, Karnataka, and Kerala.

Land features. The Western Ghats dominate the western flank. These hills form two main groups, the Nilgiris in the north and the Palani, Cardamom, and Annamalai hills in the south. The Nilgiris cover an area of about 2,500 square kilometres. Ootacamund, one of India's most famous hill resorts, is at their centre. The hills consist of rocks more than 3,000 million years old, and rise to heights of over 2,500 metres. The highest mountain in south India, Anai Mudi (2,694 metres), is in Tamil Nadu.

To the east of the hills lie the plains. They are broken in the north by isolated uplands such as the Shevaroy and Javadi hills, which reach heights of over 1,500 metres. Along the coast is a flat alluvial plain. There are deltas where major rivers, especially the Kaveri, have deposited *alluvium* (fertile soils and silts) over many hundreds of years. The deltas are famous as the *rice bowls* of Tamil Nadu. They were once the centre of the major Tamil kingdoms. In the south are the arid plains of Madurai and Ramanthapuram.

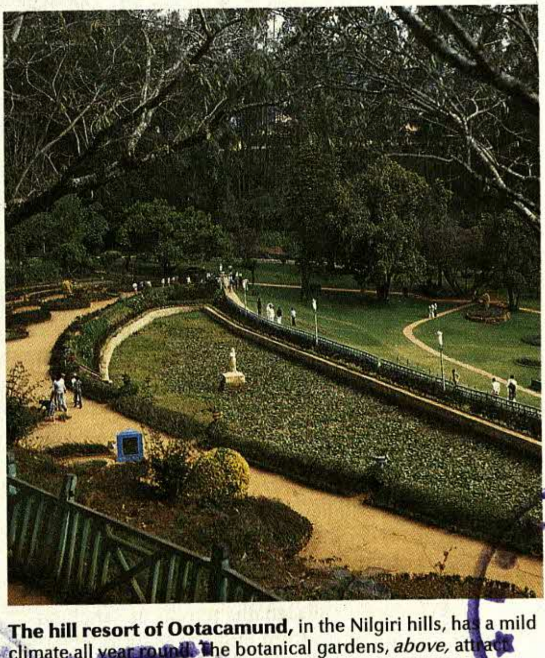
Climate. On the plains, temperatures are always quite high. In Madras, the average January temperature is about 25° C. The difference between winter and summer is not as great as in north India, and the average temperature in May, the hottest month, is about 33° C. However, temperatures are greatly affected by altitude. Kodaikanal, for example, at a height of over 2,500 metres, is about 15 degrees cooler than Madras, and occasionally has night frosts in winter. Because most of Tamil Nadu lies to the east of the Western Ghats, the climate is much drier than that on the west coast. The plains to the east lie in the rainshadow of the mountains. Strong winds blow across the plains in the early *monsoon* season, but as they come down the eastern slopes of the hills they warm up and become drier (see **Monsoon**). The districts around Madurai receive less than 75 centimetres of rain per year. The extreme southeast experiences almost desert conditions with less than 60 centimetres per year.

The change of landscape between Trivandrum and Madurai around India's southern tip illustrates the dramatic effects on vegetation and agriculture of this sudden decrease in rainfall. Tamil Nadu, and particularly the area around Madras, has an exceptional rainfall pattern. It has about 120 centimetres of rain each year, most of which falls in what is sometimes called the *retreating monsoon.* From October to December, weather depressions move across the east coast around Madras from the Bay of Bengal. They bring heavy rains, often accompanied by storms, to the coastal belt, which decrease inland and southward from Madras. It is a season when cyclonic storms, from the east and southeast over Malaysia, also strike parts of the south Indian coast as they move first west and then north up the Bay of Bengal. Such cyclones can cause enormous disruption, damage, and loss of life, particularly when they strike densely populated parts of the country.

Rivers and lakes. The state's most important river is the Kaveri. It rises in Karnataka within 100 kilometres of the west coast. Farmers use its water to irrigate the Thanjavur Delta between Tiruchirappalli and the sea. It is so shallow that a person can walk across it ankle-deep at its mouth. Other rivers include the Palar in the north and the Tambraparani in the south. Like all rivers in peninsular India, they are often dry, reflecting the seasonal nature of the rainfall on which they depend. The building of the Mettur Dam on the Kaveri River in 1926 created Tamil Nadu's biggest lake.

History

Evidence from various sites in southern India shows that there were Stone Age settlers in what is now Tamil Nadu about 200,000 years ago. Stonebuilt burial sites are common in several parts of the region. Dravidians



The hill resort of Ootacamund, in the Nilgiri hills, has a mild climate all year round. The botanical gardens, *above,* attract many visitors.

22.6.2010
14030

Shore temples at Mahabalipuram were built in the A.D. 700's. They contain shrines to the Hindu gods, Vishnu and Shiva.

moved into the south of India in about 3000 B.C. They now make up the great majority of its people.

The people of Tamil Nadu had developed an Iron Age culture by about 1000 B.C. By about 300 B.C., Tamil Nadu was under the rule of three dynasties. The Cholas occupied the coastal area east of Thanjavur and inland to the head of the Kaveri Delta at Tiruchi. At various times, they were a strong military power. One of their princes, Elara, conquered the island of Sri Lanka in about 100 B.C. The central area—Madurai, Tirunelveli and a part of south Kerala—was ruled by the Pandyas. The Pandyas were a great maritime trading power who had connections with the Roman Empire up to about A.D. 500. The Cheras controlled much of what is now Kerala on the west coast of the peninsula, but they also penetrated southern Tamil Nadu.

From around A.D. 100, a poets' academy known as the *Sangam* flourished in Madurai. According to legend, poets at the academy put Tamil literature through an extraordinary test. They threw books into the sacred tank of the Meenakshi Temple, and those that floated would be deemed worthy, while those that sank were considered useless. The writings of that period show that life in Tamil society was very different from that in the north of India. In Tamil Nadu, the wise men were at the top of society, followed by peasants, hunters, artisans, soldiers, fishermen, and scavengers. This contrasted with the caste system that existed in the rest of the subcontinent (see **Caste**).

The Pallavas became powerful in the 300's and ruled northern Tamil Nadu from 550 to 869. They were also great builders and adventurers. Mahabalipuram became an important port and naval base in the 600's. The Pallavas were mainly *Shivaites* (followers of Shiva, the Hindu god), and during the 700's they built the Mahabalipuram shore temples. Their king, Narasinhavarman II, also built the great Kailasanatha temple at Kanchipuram, about 70 kilometres from modern Madras. For 150 years, this was not only the administrative centre but also the literary and artistic capital where scholars studied Sanskrit and the Vedas (see **Vedas**).

The Cholas returned to power in 850 and remained a dominant political force until 1173. Within a hundred years, during the reign of Rajaraja, they defeated the Pandyas and the Cheras. Their great empire expanded to cover the whole Tamil area, Sri Lanka, the region of the Andhras, southern Karnataka, and the Laccadive and Maldive islands. At his capital, Thanjavur, Rajaraja I built the Brihadishwara Temple, one of the finest examples of Dravidian architecture.

There was further expansion in the 1000's during the reign of Rajendra Chola (1014-1044). He conquered Kerala and the Pandyan lands in the south, and led raids to the north and northeast. On his return he founded the city of *Gangakondacholapuram* (the city of the Chola who brought the Ganges) in the Kaveri delta. His naval expeditions to the Malayan Peninsula resulted in Chola domination over the trade routes in that area of the Indian Ocean and control of the sea routes to Java, Sumatra, and China. One other major result was the Hindu influence on the art of Java and Bali. Chola control over this vast area continued for nearly a hundred years until the Pandyas became powerful again and ruled from about 1175 to 1300. In Karnataka, the Hoysalas came to power in 1022 and emerged as a strong force (see **Karnataka**).

Tamil Nadu also came under the influence of the Vijayanagar Empire, the last Hindu empire in India, which superseded the Pandyas. After the disintegration of the Vijayanagar Empire, the Tamil region came under the control of several petty chiefs.

Places to visit

Following are brief descriptions of some of Tamil Nadu's interesting places to visit:

Chidambaram is famous for its Nataraja temple, dedicated to the god Shiva.

Kanniyakumari is at the southern tip of India, where the Arabian Sea, the Indian Ocean, and the Bay of Bengal meet. It is an important place of pilgrimage for Hindus.

Madurai is the centre of Tamil culture. Its most famous building is the Minakshi Temple. In addition to its magnificent *gopurams* (gateways), it has a spectacular hall of a thousand pillars. Each pillar is individually carved.

Ramesvaram is remembered by Hindus as the place from which Rama went to Sri Lanka to find his wife Sita, who had been abducted by the demon god Ravana. The massive Ramalingesvara Temple dates mainly from the 1500's and 1600's.

Thanjavur was the great capital of the Chola emperors from the 800's to the 1000's. The Brihadisvara Temple, built by King Rajaraja I, is a World Heritage Monument. Built between 985-1012, it has a 14-storey tower, and superb stone sculptures.

Tiruchirappalli, known as Trichy, has both famous temples and a fort perched on a rocky crag overlooking the town. The temple town of Srirangam, 3 kilometres north of Trichy, is on an island in the middle of the Kaveri River. It has magnificent gateways and several shrines.

Vellore is famous today for its Christian Medical College Hospital, regarded as one of the best in Asia. A superb small temple in the fort is one of the best examples of building by the Hindu kings of the Vijayanagar Empire.

The arrival of the British in the area in the 1600's brought far-reaching changes. Under British rule, the region became united under a single administration.

During the 1600's and 1700's, the British East India Company established its power in southern India. In 1639, the Company set up its factory at Fort St. George, the trading post that developed into the present-day city of Madras. From this centre, the company directed its political and trading activities. Through wars, annexations, and treaties with Indian rulers such as the nawab of Carnatic, the nizam of Hyderabad, and the sultan of Mysore, the East India Company acquired the territory covering the present-day Tamil Nadu.

British rule caused considerable opposition and resistance, particularly from local Indian rulers who had lost their lands to the Company. Veera Pandya Kattaboman of Tirunelveli, was one of many leaders in the Tamil region who fought against the British. The nationalist movement of the late 1800's and early 1900's aroused considerable enthusiasm in Tamil Nadu. The Non-cooperation, Civil Disobedience, and Quit India movements all received popular support there.

V. O. Chidambaram Pillai helped in the restoration of national honour and self-respect by starting the Indian Steam Navigation Company. Subramanya Bharati woke national feelings in Tamil Nadu through his poems.

A non-Brahmin movement arose in the early 1900's. Its early political organization was the Justice Party, led by Theagaraya Chetty and T. M. Nair. The Self-respect Movement initiated in 1925 by E. V. Ramaswami Naicker (called Periyar) gave a social and cultural dimension to the non-Brahmin movement. In 1944, Periyar founded Dravida Kazhagam, a social organization dedicated to the ideal of establishing a separate Dravidian country. Annadurai, one of Periyar's close disciples, formed a political party, the Dravida Munnetra Kazhagam, with the same objective. The Dravida Munnetra Kazhagam later gave up its idea of breaking away from India.

Madras is the capital and commercial centre of Tamil Nadu. Modern offices contrast with traditional architectural styles.

At the time of Indian independence in 1947, Tamil Nadu was a part of a British (United Kingdom) administrative unit called the Madras presidency. In 1956, according to the recommendations of the States Reorganization Committee, Tamil-speaking areas were formed into a separate state called Madras. In 1968, Madras state was renamed Tamil Nadu. Rajiv Gandhi, a former prime minister, was killed by a bomb at an election meeting at Madras in 1991. Investigations have established the involvement of Liberation Tigers of Tamil Elam (LTTE) in the assassination. The LTTE has been banned in India and attempts have been made for the extradition of its leader, Prabhakaran, from Sri Lanka.

Related articles in *World Book* include:

Chola Empire
India, Art of
India, Dance and music of
India, History of
India, Languages of
India, Literature of
Madras
Narasinhavaram II
Vijayanagar Empire

Outline

- **I. People and government**
  - A. People
  - B. Government
- **II. Economy**
  - A. Agriculture
  - B. Manufacturing
  - C. Mining
  - D. Transportation
  - E. Communications
- **III. Land**
  - A. Location and description
  - B. Land features
  - C. Climate
  - D. Rivers and lakes
- **IV. History**

Tammar is an extremely small wallaby. It has brown fur and a white throat, chest, and belly. Some are 60 centimetres high. Females weigh 4 kilograms and males weigh about 6 kilograms. Tammars live on a number of coastal islands, from the Abrolhos on the west coast of Australia to Kangaroo Island in South Australia. They also live on the nearby mainland, in forest and scrub country.

Tammars have a breeding feature known as *delayed implantation.* This means that if a female mates soon after giving birth, the resulting embryo remains in an early stage of development. If the young wallaby in the pouch dies or leaves, the embryo, or *blastocyst,* as it is called, resumes development and is born in normal fashion. The tammar is remarkable in that it can sustain the blastocyst for as long as 11 months, the longest period of any mammal.

Scientific classification. The tammar belongs to the family Macropodidae. It is *Macropus eugenii.*

Tampa, Florida (pop. 280,015), is a major United States seaport, an important commercial and industrial centre, and Florida's third largest city. It lies on the northeast shore of Tampa Bay, an inlet from the Gulf of Mexico.

The Port of Tampa handles more cargo than any other Florida port—about 45 million metric tons yearly. The port's annual exports include about 9 million metric tons of phosphate ore from nearby mines. Fishing fleets based in Tampa catch large amounts of shrimp and other seafood.

Tampere (pop. 167,344; met. area pop. 249,606) is Finland's second largest city and industrial centre. Only Helsinki has more people and industry. Tampere lies in southern Finland between Lakes Näsijärvi and Pyhäjärvi. For location, see **Finland** (political map).

Tampere's chief industries are food and metal processing and paper and textile production. The Tammerkoski River and waterfalls run through the city. Tampere has abundant parks and other recreational areas. It is the home of the University of Tampere. Most of the city's people live in blocks of flats. Some of its suburbs stand on beautiful ridges overlooking the lakes.

During the Middle Ages, the site of what is now Tampere was an important market and milling centre. King Gustavus III of Sweden and Finland established Tampere as a city in 1779. The city began its industrial growth in the mid-1800's.

Tampico (pop. 267,957) is the second most important port in Mexico, after Veracruz. It stands 11 kilometres west of the Gulf of Mexico on the Pánuco River (see **Mexico** [political map]). Tampico serves as a refining centre for Mexico's petroleum industry and is the chief outlet for oil exports. A mild winter climate and good hunting and fishing make it a favourite resort centre. Spaniards settled the city in the 1500's.

Tamworth (pop. 68,900) is a borough and local government district in Staffordshire, England. It stands on the rivers Anker and Tame and has a Norman motte and bailey castle built shortly after 1066. Tamworth's workers make paper, insulating equipment, soft drinks, and cars. Sir Robert Peel, a British statesman of the early 1800's, was once MP for Tamworth. See also **Staffordshire.**

Tamworth (pop. 35,068) is a city in New South Wales, Australia. It is located on the Peel River about 410 kilometres north of Sydney. Tamworth is known for the Australasian Country Music awards, which have been presented there each year since 1973. It is the centre of a rich agricultural area, producing wool, wheat, dairy products, eggs, honey, and grain crops. The area's mineral deposits include asbestos, tin, copper, and gold. Tamworth is an industrial centre with many factories. The city has an agricultural research station and a technical and further education college.

Tan Chee Khoon (1919-   ), a popular politician, became known as *Mr. Opposition* because of the role he played in the Malaysian parliament.

Tan Chee Khoon was born in Kuala Lumpur and trained as a doctor in Singapore. He opened a practice in Kuala Lumpur and joined the Labour Party, the main political party in Malaysia not oriented toward a particular racial community. In 1964, Tan was elected as a Labour member of parliament. When the Socialist Front broke up in 1966, the Labour Party withdrew from constitutional politics. Tan and a few others founded the *Gerakan Rakyat Malaysia* (The Malaysian People's Movement) in 1968. This party split up into opposing groups, and Tan left to found the *Pekemas* (Social Justice Party) in 1970. He resigned because of ill health in 1976. Pekemas was disbanded in 1981.

Tan Cheng Lock (1883-1960), later known as Sir Cheng-lock Tan, was a Chinese political leader in Malaya. Born in Melaka, he was educated at Melaka High School and the Raffles Institution in Singapore.

From 1928 to 1935, Tan Cheng Lock headed the Straits Chinese British Association of Melaka. When the Japanese occupied Malaya in 1942, he fled to India and stayed there until 1946. While there, he conceived the idea of a Malayan Chinese political party. In 1949, he helped to found the Malayan Chinese Association (MCA) and became its first president. In the negotiations with the British for Malayan independence, the MCA represented the Malayan Chinese community.

Tan Cheng Lock was a Straits Chinese who, unlike the Chinese immigrant population of Malaya, was a British subject. This was the basis of his rise to influence under the British. He received a knighthood in 1952.

Tan Kah Kee (1874-1961), a Singapore businessman, was one of Southeast Asia's most outstanding industrialists, philanthropists, and political leaders. He founded a number of schools in Singapore and southern China.

Tan Kah Kee was born in Chi Mei village, Fujian, southern China, and arrived in Singapore in 1890. In 1904, he began canning pineapples. In 1906, he added rubber planting and rice milling to his business activities. Tan Kah Kee became known as the "Henry Ford of Malaya" for the business empire that he created. He helped raise large amounts of money to assist China after various natural disasters. In 1921, he founded a university at Amoy in China and financed it for more than 10 years. Tan Kah Kee also gave money to assist the Chinese in their war against the Japanese during the 1930's.

Tan Malaka (1896?-1949), an Indonesian Communist, played an important part in his country's struggle for independence from Dutch rule.

Tan Malaka was born in Minangkabau, Sumatra. His original name was *Sutan Ibrahim.* In 1912, his parents gave him the *gelar* (title) Tan Malaka. In 1913, he was sent for further education in the Netherlands, where he became interested in Communism.

Tan Malaka returned to Indonesia in 1919. He worked as a teacher before becoming a leading figure in the Communist movement. Following his support for a strike in 1922, he was exiled by the Dutch colonial government and went back to the Netherlands. There he stood for parliament as third candidate on the Communist list, but failed to receive enough votes to gain a seat. Later in 1922, Tan Malaka went to Moscow to attend the fourth congress of the Comintern, an international Communist organization, as the Javanese delegate. In 1926, he opposed the Indonesian Communist Party's plans for a revolt and broke with the party.

Tan Malaka spent about 20 years in China, the Philippines and other countries, where he disguised himself and used false names.

He returned to Java in 1944, during the Japanese occupation, but still concealed his identity. After the Japanese surrender in 1945, Tan Malaka revealed his identity and rapidly acquired influence in the struggle for Indonesian independence. He was arrested and imprisoned, but was released in 1948. After the unsuccessful Communist uprising at Madiun that year, Tan Malaka took over leadership of the socialist movement and called for total resistance to the Dutch. In February 1949, he and an army unit clashed with another group of Indonesian soldiers, supporters of Sukarno, Indonesia's first president. Tan Malaka was captured and executed.

Tan Tock Seng (1798-1850) became a leader of the Chinese community in Singapore. In 1844, he became a justice of the peace.

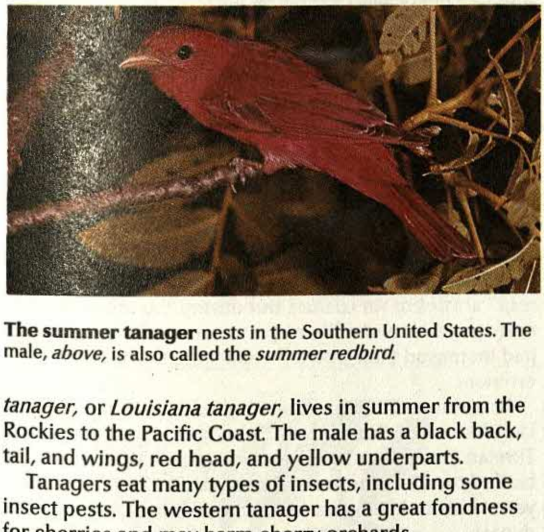
Tan Tock Seng was born in Melaka, in what is now Malaysia. He arrived in Singapore in 1819. He began selling vegetables, fruit, and chickens and later opened a small shop. His business flourished and he used his wealth to help other Chinese immigrants. In 1844, he built the first hospital in Singapore for Chinese *paupers* (poor people). The hospital, which still bears his name, is now one of the largest hospitals in Singapore.

Tana, Lake. See **Lake Tana.**

Tanager is the common name given to a subfamily of American birds, many of which have brilliant red, blue, or green feathers. Tanagers are from 15 to 20 centimetres long, and are usually found in forests, where they feed on insects, fruit, and flowers. There are more than 200 species of tanagers, most of which live in Central and South America. Only a few species of tanagers live in the United States.

The well-known *scarlet tanager* has a loud, cheery song somewhat like that of the robin. Scarlet tanagers nest in the Eastern United States and as far north as eastern Canada. They are sometimes called *firebirds.* The male has bright red feathers, with velvety black wings and tail. The female is dull yellow below and olive green above, with darker wings and tail. The tanager builds its frail, saucer-shaped nest near the end of a horizontal limb. The female lays three to five bluish-green eggs with reddish-brown markings.

In the Southern United States, the *summer tanager* is a familiar bird. It has rosy-red feathers. Its nesting habits are much like those of the scarlet tanager. The *western tanager,* or *Louisiana tanager,* lives in summer from the Rockies to the Pacific Coast. The male has a black back, tail, and wings, red head, and yellow underparts.



The summer tanager nests in the Southern United States. The male, *above,* is also called the *summer redbird.*

Tanagers eat many types of insects, including some insect pests. The western tanager has a great fondness for cherries and may harm cherry orchards.

Scientific classification. Tanagers make up the tanager subfamily, Thraupinae. The scarlet tanager is *Piranga olivacea;* the summer tanager is *P. rubra;* the western tanager is *P. ludoviciana.*

See also **Bird** (picture: Birds' eggs).

Tananarive. See **Antananarivo.**

Tandridge (pop. 75,000) is a local government district in Surrey, England. It contains Caterham, Oxted, Warlingham, and Whyteleafe. It also includes Limpsfield, where Frederick Delius is buried, and Lingfield, well known for its racecourse. Many London workers live in Tandridge. Other residents of the district work in arable and dairy farming or light industry. A firm producing helicopters is based at Redhill Aerodrome. The Pilgrims' Way (a long-distance footpath) and the M23 and M25 motorways pass through Tandridge district. See also **Surrey.**

Tang dynasty was a series of rulers who governed China from A.D. 618 to 907. Many historians consider the Tang period the golden age of Chinese civilization. The dynasty's capital city, Chang'an (now Xian), became one of the great cultural centres of the world. Artists, poets, scholars, and government and religious leaders from many countries visited Chang'an and the Chinese coastal trading centres.

The Tang rulers united China and established a strong central government. They carefully hand-picked their chief officials. The Tang emperors also set up a council of ministers to act as advisers. In addition, the emperors sent inspectors into the provinces of China to check on the activities of local governors.

The Tang rulers also promoted trade, which became the basis of the empire's great prosperity. Jade, porcelain, rice, silks, spices, tea, and other Chinese products flowed to India, the Middle East, and Europe along trade routes opened by the Tang emperors.

During the Tang period, the Chinese invented block printing, which soon replaced the handwritten scriptures of the Chinese Buddhists. In 868, the Chinese produced the *Diamond Sutra,* the world's first block-printed book.

The rise of the dynasty. The Tang dynasty followed the Sui dynasty, which had ruled China from A.D. 589 to 618. Li Yuan, an aristocrat, overthrew the Sui emperor and became the first Tang ruler (see **Li Yuan**). He set up his capital at Chang'an, in northwestern China. *Chang'an* meant *long peace,* but China was soon torn by civil war. In addition, a struggle for power developed among the nobility. In 627, Li Yuan turned the control of China over to his son, Li Shimin, who took the name Tang Taizong (also spelled *Tang Tai-tsung*). Taizong ruled for 22 years and became one of the greatest emperors in Chinese history.

Taizong was a powerful leader. He destroyed his competitors for the throne, began an alliance with the Korean state of Silla, and forced Turkish nomads out of Northern China. His armies conquered parts of Tibet and Turkestan, opening overland trade routes from China to India and central Asia. The trade routes not only brought great wealth to the empire, but they also promoted religious and cultural exchange. The routes gave Christian and other foreign missionaries an overland entrance into China and allowed Chinese Buddhist pilgrims to visit India.

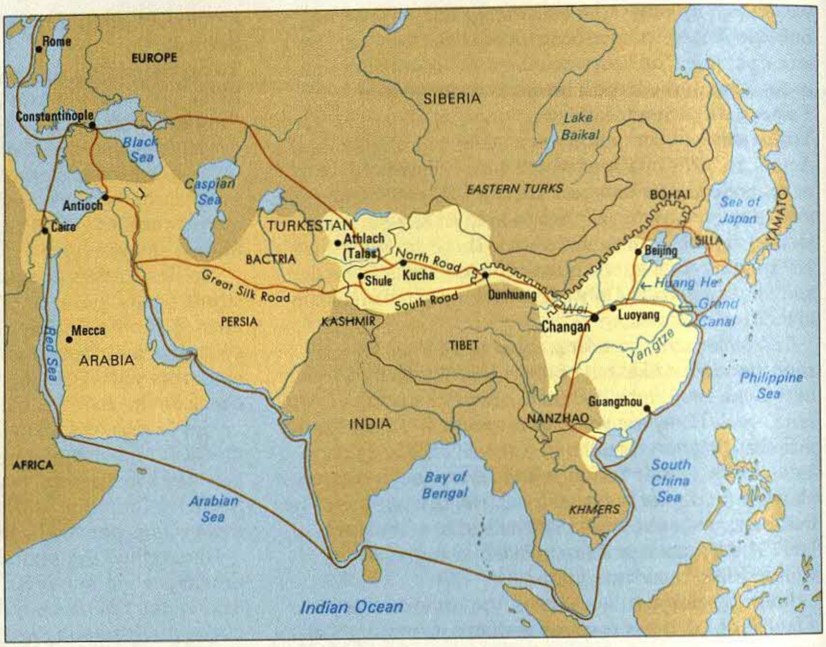
Taizong reorganized the administration of the empire. He built colleges to help select and train officials for government work. Although Buddhism was the country's main religion, Taizong knew that many Chinese who could help him carry out his programmes followed Confucianism. As a result, he named many Confucians to high government posts.

In 649, Tang Gaozong (also spelled *Tang Gao-tsung*) became emperor. But his wife, Empress Wu, soon took control of the government. Gaozong died in 683, and his son became emperor—but in name only. Empress Wu continued to control the government, and she became the second great leader of the Tang dynasty.

Empress Wu governed China with a great amount of skill. She appointed able ministers to major government

The Tang Empire in about A.D. 750

This map shows the land ruled by the Tang emperors from their capital at Chang'an. The Tang Empire reached its greatest size under Emperor Xuanzong. It controlled territory from eastern China to Persia. Arabs defeated Chinese armies at Athlach in A.D. 751. This battle marked the end of Tang power in Turkestan and the closing of overland trade routes to the west.



posts and had the complete loyalty of her advisers and officials. Empress Wu maintained the high reputation of the Tang dynasty abroad because of her political brilliance. The empress also showed great favouritism to Buddhism and promoted art and literature. During the late 600's, Tibet forced the Chinese out of Turkestan. To protect China's trade routes there, Empress Wu sent her armies into the region and recovered the Tang territory.

The middle years. Tang Xuanzong, the grandson of Empress Wu, became emperor in 712. Xuanzong, also known as Ming Huang, was the last of the three great Tang rulers. During his reign, China produced some of its best artists and such great poets as Li Bo (also spelled *Li Po*) and Du Fu (also spelled *Tu Fu*). Xuanzong's economic programmes, including the development of new farming regions in the Yangtze Valley, greatly increased China's wealth.

In 747, China reached its peak of influence in western Asia. Tang armies invaded Bactria and Kashmir and defeated an Arab-Tibetan alliance that had been formed against China's allies in central Asia. But in 751, a revolt in Turkestan closed China's trade routes to the Middle East.

The Snite Museum of Art, University of Notre Dame, Notre Dame, Indiana, U.S.A.

Figures of four female musicians illustrate the simple charm of pottery figures of the Tang dynasty. The figures were created to be placed in a tomb when a person was buried.

When Xuanzong was more than 60 years old, he fell in love with his son's wife and took her as his mistress. She soon gained control over the emperor and made him appoint a cunning Manchurian military governor, An Lushan, to the royal court. In 755, An Lushan organized a rebellion against Xuanzong and captured and briefly occupied the capital of Chang'an. In 756, Xuanzong turned the throne over to his son, Suzong. In 766, a combination of Chinese and foreign troops defeated the rebel armies of An Lushan. But during the rebellion, army generals and military governors in the provinces had increased their power, weakening the central government.

In addition, Tibet had been united into a powerful kingdom while Suzong was fighting An Lushan. In 763, Tibetan forces invaded China. Forces of the Tang rulers battled the Tibetans in northwestern China for about 80 years. This long conflict further weakened the Tang dynasty.

The fall of the dynasty. Border wars and rebellions in the provinces troubled China between 766 and 868. Yet the Tang dynasty remained prosperous, largely because of a new tax system. The Chinese had been required to pay their taxes with labour and goods. Under the new system, they could also pay with cash. This new system was more efficient than the older one and provided increased income.

In 868, a second long and powerful military revolt broke out against the Tang dynasty. In 881, peasant rebels led by Huang Chao captured the capital of Chang'an. One by one, the governors of the provinces declared their independence from the central government of the Tang dynasty.

In 907, the Tang dynasty finally came to an end. Until the Song dynasty gained control of China in 960, the country was governed by a series of short-lived military dynasties.

See also **China** (The Tang dynasty; picture: Multicolour ceramics).

Tanganyika. See **Tanzania.**

Tanganyika, Lake. See **Lake Tanganyika.**

Tange, Kenzo (1913-), is a Japanese architect. His work blends modern glass and concrete building systems with traditional Japanese styles. He won fame for the Peace Hall built on the site of the atomic bomb explosion at Hiroshima, Japan.

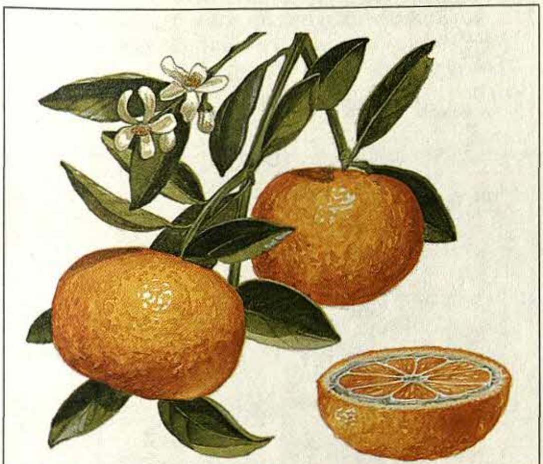
Tange was born in Osaka, Japan. He studied at Tokyo University, where he was professor of architecture from 1946 to 1974. After the Hiroshima Peace Hall (1949-55), he designed Tokyo City Hall and the Roman Catholic Cathedral, Tokyo. In 1960, Tange devised a radical, though unbuilt, scheme to extend Tokyo into Tokyo Bay. In 1964, he won praise for his sweeping roof for the National Gymnasium for the Tokyo Olympic Games.

Tange later concentrated on urban planning, with designs for Skopje, Yugoslavia (1965-66), and Bologna, Italy (1971). He also designed the Royal Palace in Jeddah, Saudi Arabia (1977-82), and the Abuja urban scheme in Nigeria (1979).

Tangelo is a mandarin citrus fruit that results from cross-pollination between a tangerine and a grapefruit. The word tangelo comes from *tang*erine and pom*elo*, another name for grapefruit. Tangelos have thin peels and a delicious flavour. Important varieties include the Minneola and the Orlando, both from the United States. The Ugli is a Jamaican tangelo that is widely grown in the West Indies.

See also **Tangerine; Tangor.**

Tangerine is the popular name for a citrus fruit of the mandarin group. This fruit looks like an orange, but is smaller and flatter, peels more easily, and the sections separate more readily. The tangerine is an orange-red mandarin fruit which originated in Southeast Asia. It has a thin, fragrant peel. The fruit is delicate, but the tree is more resistant to cold than is the orange tree. Varieties of tangerines include Clementine, Dancy, Ponkan, and hybrid varieties such as Kinnow, Robinson, Sunburst, and Wilking. Tangerines are grown in Brazil, China, Italy, Japan, Spain, and the United States.



The tangerine is a popular citrus fruit. Tangerines are smaller than oranges, peel more easily, and have a delicate taste.

Scientific classification. The tangerine belongs to the rue family, Rutaceae. It is *Citrus reticulata.*

See also **Tangelo; Tangor.**

Tangier (pop. 266,346), also spelled *Tanger,* is a city on the northern coast of Morocco. It lies along the Strait of Gibraltar, which connects the Atlantic Ocean and the Mediterranean Sea. For location, see **Morocco** (map). Tangier is the capital of the province of Tangier. It ranks second only to Casablanca among Morocco's seaports and is the country's main port for passenger vessels. From the sea, the city looks like an amphitheatre, with rows of white houses lining its hills.

Most of the people of Tangier are Arabs or Berbers. But Spanish and French—as well as Arabic and Berber—are widely spoken there. Tangier is a centre of shipping and tourism. It has few manufacturing industries.

In ancient times, Phoenicians and Romans built settlements near what is now Tangier. The city came under Arab control in the 700's. Portugal, Spain, and England held Tangier at different times from the 1400's until the late 1600's, when the sultan of Morocco gained control. In 1912, Morocco fell under the control of France and Spain. But Tangier remained free from control by any one European nation, though the sultan granted special privileges to several European countries. In 1923, the major European powers placed the city under international control.

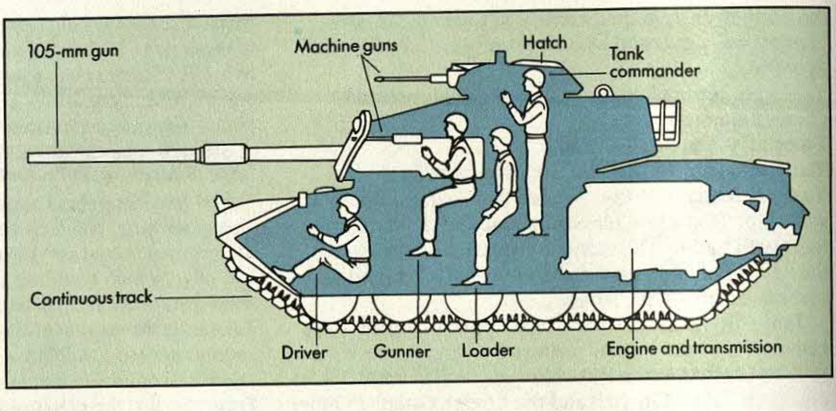
In 1956, when Morocco gained its independence from France and Spain, the sultan of Morocco called a conference of the nations that controlled Tangier. The nations voted to end the city's international status, and to give up most of their former rights in the area. Tangier then came back under the control of Morocco.

Tango was the first Latin American dance to gain great international popularity. The tango is a ballroom dance in slow $\frac{2}{4}$ time with an irregularly accented beat. The dancing couple glide smoothly through a variety of step patterns. They alternate long, slow steps with short, quick steps, and strike elaborate poses. The music for this dance is also called *tango,* and is very dramatic.

Today's tango probably began as an Argentine dance called the *milonga* and includes elements of the Andalusian tango from Spain and the Cuban *habanera.* At first, the tango was considered indecent. But people liked the steps and rhythm so much that they modified the dance into a more acceptable form. The tango was popularized in the United States in about 1912 by Vernon and Irene Castle, a famous ballroom dance team. It also became popular in Paris and London.

Tangor is a citrus fruit that belongs to the mandarin family (see **Mandarin**). It is produced by cross-pollination between a tangerine and an orange. The parents of tangors are seldom known for certain, except when the fruits result from carefully controlled plant breeding programmes. The *Temple* and the *Honey Tangerine* are among the most important tangors cultivated today.

Tank is an armoured combat vehicle. Most tanks travel on continuous tracks. They carry such weapons as can-



The crew and basic parts of a tank

This diagram of a U.S. Army M60A1 main battle tank shows the position of the crew members, plus some parts of the vehicle. The crew consists of a commander and three other people. One crew member drives the tank, one loads the guns, and the other two fire the guns. The tank has a 105-mm gun and two machine guns.

nons, machine guns, and missile launchers. In most tanks, these weapons are mounted in a revolving structure called a *turret.* A tank has a crew of three to five members.

Tanks are used to attack other armoured vehicles, infantry, and ground targets; and to fire on aircraft. Armies throughout the world have a total of more than 150,000 tanks. Tanks are classified as *main battle tanks* or as *armoured reconnaissance vehicles.* Main battle tanks weigh from 32 to 54 metric tons. Armoured reconnaissance vehicles weigh from 9 to 23 metric tons.

Performance. Tanks travel as fast as 80 kilometres per hour on level ground. They average only 16 to 32 kilometres per hour on rough terrain. Tanks can climb and descend slopes as steep as 30 degrees, and can turn around within their own length.

The newest tanks have 100- to 125-millimetre guns, which can be combined with computer fire control systems. These guns can hit small targets 1.5 kilometres away, even if the tank is moving. The new tanks also have heavy armour that can withstand attack by conventional and nuclear weapons.

History. Tanks got their name from the British, who developed the tank during World War I (1914-1918). While they were being built, the British called them water tanks to conceal their purpose. The British first used tanks against the Germans in the Battle of the Somme in 1916. The early tanks were very slow and clumsy, but they were used successfully in the Battle of Cambrai in 1917.

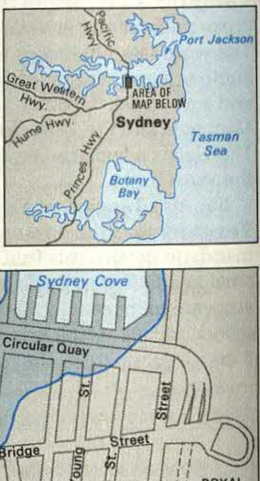
During World War II (1939-1945), all the warring nations used tanks. The speed and surprise of German tank units won important victories over Poland, France, and the Soviet Union. In 1943, the Soviets defeated the Germans at Kursk, in the Soviet Union, in the greatest tank battle in history, in which thousands of tanks took part. In 1944, Allied tanks swept into Germany, helping ensure victory in Europe.

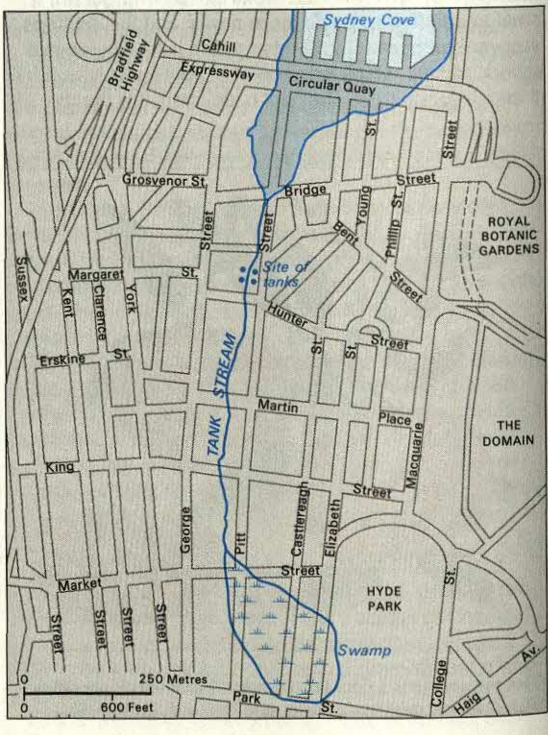
Since World War II, tanks have taken part in many regional wars, especially in the Middle East. More than 6,000 tanks were used in the Arab-Israeli war of 1973. Nearly half the tanks were destroyed in only 18 days of combat. During this war, precision-guided weapons were used against tanks for the first time. Despite the high tank losses, the vehicles were effective when given infantry and artillery support.

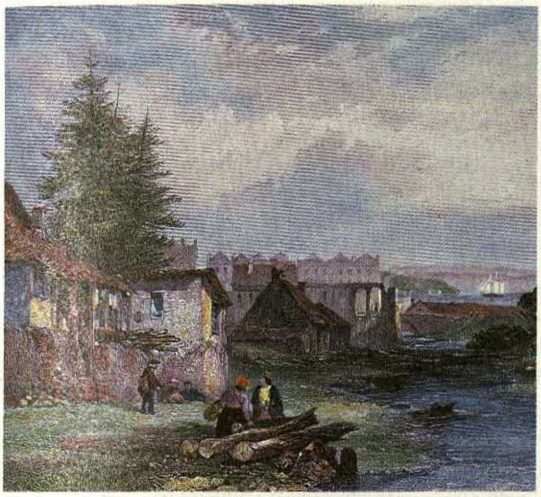
See also **Periscope; World War I** (picture); **World War II** (picture).

Tank Stream, in Sydney, was a watercourse that rose on the Hyde Park plateau and flowed north to enter Sydney Cove near Bridge Street. It provided Sydney's first water supply. In 1789 and 1790, convicts excavated several water storage tanks that gave the stream its name. The Tank Stream became greatly polluted as Sydney's population grew. By the 1860's, it had become a smelly, open drain. It was gradually confined in stone-walled

The Tank Stream was a small stream in Sydney that flowed from the Hyde Park area to Bridge Street, which was then on Sydney Cove. The water tanks, built in 1789 and 1790, gave the stream its name. Today, the Tank Stream is an underground drain. It now ends near Circular Quay, because large areas of Sydney Cove have since been filled in.







The Tank Stream provided Sydney's first water supply. The stream became so polluted that it was rendered unusable as a water supply after only three years.

channels and eventually covered and built over. The Tank Stream is now a storm-water drain well below street level. It ends at the western end of the Circular Quay ferry jetties.

Tanka. See **Japanese literature.**

Tanker is a ship designed to carry liquid cargo. Most tankers transport petroleum products, but they may also carry such products as molasses, wine, chemicals, and even coal, grain, and iron ore.

A tanker has as many as 25 tanks, the walls of which are formed in part by the hull. A crew of 25 to 40 people lives in the deckhouse, which usually stands above the engines at the stern. On most tankers, the deckhouse has five or six storeys, with the bridge on top. Cargo pumps and piping line the main deck.

Kinds of tankers. There are three chief kinds of tankers: (1) oil tankers, (2) combination carriers, and (3) liquefied natural gas carriers.

Oil tankers carry crude oil and refined petroleum products. The hull forms the outside of the tanks. *Bulkheads* (walls) run the length and width of the ship and divide the ship into compartments. This type of construction strengthens the hull. It also enables an oil tanker to carry several products—such as diesel fuel, petrol, and paraffin—at the same time.

Extra large oil tankers, called *supertankers,* were developed during the 1960's and 1970's. These ships are also known as *very large crude carriers (VLCC's)* or *ultra large crude carriers (ULCC's),* depending on their size. The largest supertanker ever built measures 458 metres long and 69 metres wide. It can hold about 550 million kilograms of oil. When filled, its hull extends 24 metres under the water. Supertankers cruise at speeds of about 15 knots and are extremely difficult to manoeuvre. A VLCC making an emergency stop may travel over 5 kilometres before stopping completely.

Most supertankers are used to transport oil from the Middle East to Europe and Japan. In those areas, supertankers load and unload cargo through underwater pipelines provided by offshore ports.

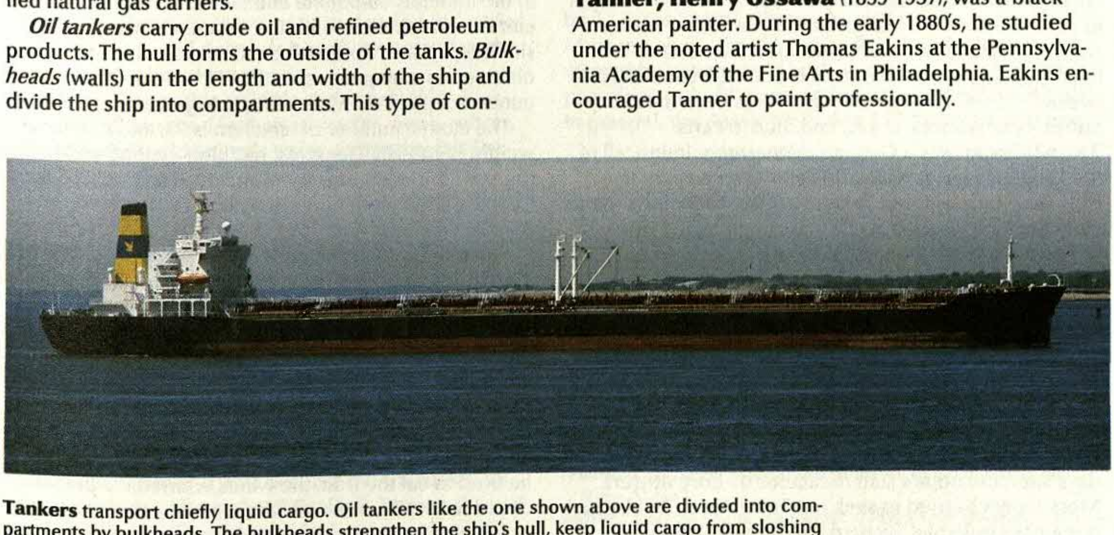
Combination carriers carry such cargoes as grain and ore, as well as oil. These ships are divided into two groups, *ore-oil carriers (O/O's)* and *bulk-oil carriers (B/O's).* They have tanks and pumps for storing and unloading liquids. They also have large hatches on the main deck for loading and unloading dry cargo.

Liquefied natural gas (LNG) carriers were developed in the 1960's. When natural gas is chilled to −162° C, it shrinks to about $\frac{1}{600}$ of its volume and becomes liquid. Plants on shore liquefy natural gas and pump it into specially insulated tanks on the tankers.

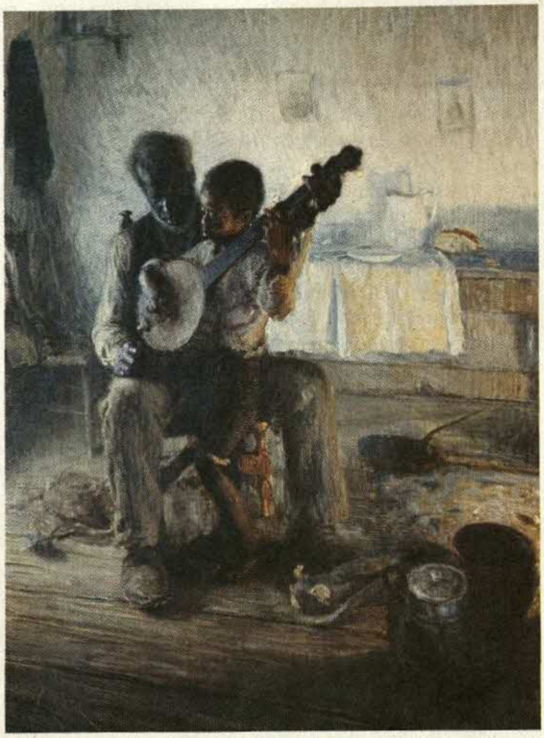
Water pollution by tankers. Tankers spill about 1.1 billion kilograms of oil into the world's seas annually as a result of accidents and normal ship operations. The oil industry has taken steps to reduce pollution. Some tankers have double hulls to minimize the loss of oil in accidents. Methods have been developed to help prevent spilled oil from spreading over the water and to help remove spills from its surface. Steps have also been taken to prevent the discharge of oily seawater carried in the deepest holds to stabilize the ship.

See also **Ship** (Tankers; pictures); **Petroleum** (diagram: How oil is transported).

Tanner, Henry Ossawa (1859-1937), was a black American painter. During the early 1880's, he studied under the noted artist Thomas Eakins at the Pennsylvania Academy of the Fine Arts in Philadelphia. Eakins encouraged Tanner to paint professionally.



Tankers transport chiefly liquid cargo. Oil tankers like the one shown above are divided into compartments by bulkheads. The bulkheads strengthen the ship's hull, keep liquid cargo from sloshing around, and allow the ship to carry more than one product at the same time.



Oil painting on canvas; Collis P. Huntington Memorial Library, Hampton Institute, Hampton, Virginia, U.S.A.

Tanner's *The Banjo Lesson* shows the painter's sympathetic treatment of life among Southern blacks in the United States during the late 1800's.

Tanner's early works reflect the influence of Eakins' realistic style. Tanner first gained recognition for his pictures of black life on plantations. Perhaps his best-known early work depicting this theme is *The Banjo Lesson.*

In 1891, Tanner moved to Europe to continue his studies and to escape the racial prejudice he had experienced in the United States. He settled in Paris and began to paint pictures with religious themes. These works show the influence of the Dutch artist Rembrandt in their glowing, warm colours and dramatic contrasts between light and dark areas. Tanner was born in Pittsburgh, Pennsylvania, U.S.A., and died in Paris.

Tannhäuser was a German *minnesinger* (minstrel) of the 1200's. He led a restless life and even went to the Holy Land on a crusade. A ballad of the 1500's tells the story that one evening, as he was riding by the Hörselberg in Thuringia, a beautiful woman appeared before him. He recognized her as the goddess Venus. He followed her to a palace inside the mountain and spent seven years there.

Finally, Tannhäuser left Venus and went on a pilgrimage to Rome to seek forgiveness for his sins. The pope said that just as the staff he held in his hand could never blossom, so would Tannhäuser's sins never be forgiven. Tannhäuser went sorrowfully back to Germany. Three days later, the pope's staff miraculously bore flowers. Messengers hurried to seek out Tannhäuser, but he had gone back to Venus. Richard Wagner's opera *Tannhäuser* is based on this legend.

Tannic acid, also called *tannin,* is a group of chemical substances found in the bark, leaves, fruit, roots, and other parts of many trees. Tannin is obtained from such trees as oaks, mangroves, wattles, chestnuts, hemlocks, and quebrachos.

Tannins are used to tan animal hides. The hides contain gelatin that combines with the tannin, converting the hides to leather. Tannins are also used as *mordants* (dye fixatives) and in manufacturing inks.

Tannins from different sources have different chemical formulas. Different tannins produce different colours in the tanned leather. Tannic acid is a bulky powder, ranging from light yellow to brown in colour. It is soluble in water.

See also **Gall; Leather** (Tanning).

Tanning. See **Leather; Tannic acid.**

Tansy is a plant related to the thistle. The tansy first grew wild in Europe and Siberia. It is now often grown in gardens, and is common also in North America and New Zealand. The leaves and flowers of the tansy have a bitter taste and a strong odour. The leaves were once used in flavouring. These dark green leaves give off an oil which is known as *oil of tansy.* This oil is poisonous, but is used to some extent in medicines. The flowers of the tansy are yellow.

Scientific classification. Tansies make up the genus *Tanacetum* in the family Compositae (Asteraceae).

Tantalum is a chemical element with symbol Ta. It is a rare metal. At normal temperatures, a film of tantalum oxide forms on the surface of tantalum and protects the metal from corrosion. The electronics industry uses tantalum in the manufacture of capacitors because the tantalum oxide film serves as an efficient insulator. The metal is also widely used in building nuclear reactors, and in certain aircraft and missile parts. Tantalum oxide is an important component of camera lenses because it increases the *refracting* (light-bending) properties of glass. In addition, tantalum does not react with body fluids, and it is therefore ideal for such surgical applications as bone repair and internal stitching.

Tantalum occurs in nature with the element niobium in the minerals columbite and tantalite. Tantalum is difficult to separate from niobium because of the chemical similarity of the two elements. Commercially, tantalum is obtained as a by-product in the extraction of tin from mineral deposits in Malaysia and Nigeria.

The atomic number of tantalum is 73, and its atomic weight is 180.948. The metal has high melting and boiling points. It melts at 2996° C and boils at 5425° C (±100° C). Tantalum was discovered in 1802 by the Swedish chemist Anders Ekeberg.

See also **Element, Chemical** (table).

Tantalus was a king of Lydia in Greek mythology. He was the son of Zeus and the nymph Pluto. Tantalus was punished because he killed his son Pelops and served him to the gods as food. Later, Pelops was restored to life. In Hades, the land of the dead, Tantalus was forced to stand under threat of a hanging rock and up to his chin in water. When he tried to drink, the water always vanished. Fruit hung from branches above him. When he tried to eat the fruit, the winds whirled the branches out of reach. The word *tantalize,* which means to tease or torment by keeping something out of reach, is taken from his name.

Dar es Salaam, Tanzania's capital and largest city, has modern buildings and large parks. The city's harbour, *background,* has helped it become an important trading centre.

Tanzania

Tanzania is a large country in eastern Africa that borders the Indian Ocean. Most of Tanzania lies on the mainland of Africa. Several nearby islands make up the rest of the country. Dar es Salaam is Tanzania's capital and largest city. A new capital is under construction at Dodoma, in central Tanzania. The country's official name is the United Republic of Tanzania.

Tanzania's population consists mainly of black Africans. The rest are people of Asian or European descent. Tanzania is one of the world's poorest countries. About 80 per cent of its people live in rural areas and farm for a living. The government has tried to develop industries, but the economy still depends heavily on agricultural production and imported goods.

Tanzania's fascinating wildlife and spectacular scenery are world famous. Elephants, giraffes, lions, zebras, and many other wild animals roam across the vast Serengeti National Park, Selous Game Reserve, and other areas where hunting is banned or limited. Africa's highest mountain, the majestic, snow-capped Kilimanjaro, rises 5,895 metres in northern Tanzania. Lake Tanganyika, the longest freshwater lake in the world, extends 680 kilometres along the country's western border. Part of Lake Victoria, which is the largest lake in Africa, lies within northern Tanzania. The lake covers an area of about 69,485 square kilometres.

During the 1800's, Germany established a colony on the mainland of what is now Tanzania. The United Kingdom (UK) ruled a group of nearby islands, known as Zanzibar. The mainland area became the UK colony of Tanganyika during the early 1900's. Both Tanganyika and Zanzibar gained independence during the early 1960's. In 1964, they united to form Tanzania.

Government

Tanzania is a one-party state. The only legal political party, the Chama Cha Mapinduzi (CCM) or Revolutionary Party, establishes government policies.

National government. A president heads Tanzania's national government. The Chama Cha Mapinduzi nominates the president, whom the people elect to a five-year term. The president appoints a first vice president and a second vice president. One vice president serves as prime minister and the other is president of Zanzibar. If the president is from the mainland, the first vice president is from Zanzibar, and vice versa.

The National Assembly is the nation's lawmaking body. It has 244 members who serve five-year terms. Most members are elected by the people. Others are elected by government bodies, are appointed by the president, or hold membership as government officials. In general, the Assembly makes CCM policies into law.

Facts in brief about Tanzania

Capital: Dar es Salaam.
Official languages: English and Swahili.
Area: 945,000 km².
Population: *Estimated 1996 population*—31,698,000; density, 34 people per km²; distribution, 80 per cent rural, 20 per cent urban. *1978 census*—17,512,611. *Estimated 2001 population*—36,990,000.
Chief products: *Agriculture*—bananas, beef, cashews, cassava, cloves, coconuts, coffee, cotton, maize, milk, millet, rice, sisal, sorghum, sugar cane, tea, tobacco, wheat. *Manufacturing*—fertilizer, food products, textiles.
National anthem: "Mungo Ibariki Africa" ("God the Almighty Bless Africa").
Money: *Currency unit*—Tanzanian shilling. One shilling = 100 cents.

Regional and local government. Tanzania is divided into 25 regions for administrative purposes. Local government has special responsibility in the areas of agriculture, education, and health care.

Politics. The Chama Cha Mapinduzi approves all candidates for election to the National Assembly. All candidates for elective posts must be CCM members.

Courts. The Tanzania Court of Appeals is the country's highest court. Lower courts include district courts and local primary courts.

Armed forces. Tanzania has an army of more than 38,000 members. The country also has a small navy and air force. Military service is voluntary.

People

Population and ancestry. For Tanzania's total population, see the *Facts in brief* table with this article. It ranks among Africa's least urbanized nations. Only about 15 per cent of Tanzania's people live in cities. Dar es Salaam has a population of about 870,000. Other cities include Zanzibar on Zanzibar Island and Mbeya, Mwanza, and Tanga on the mainland.

More than two-thirds of Tanzania's rural population live in the northern third of the country. Areas near mountains in the north and lakes in the west have especially dense populations.

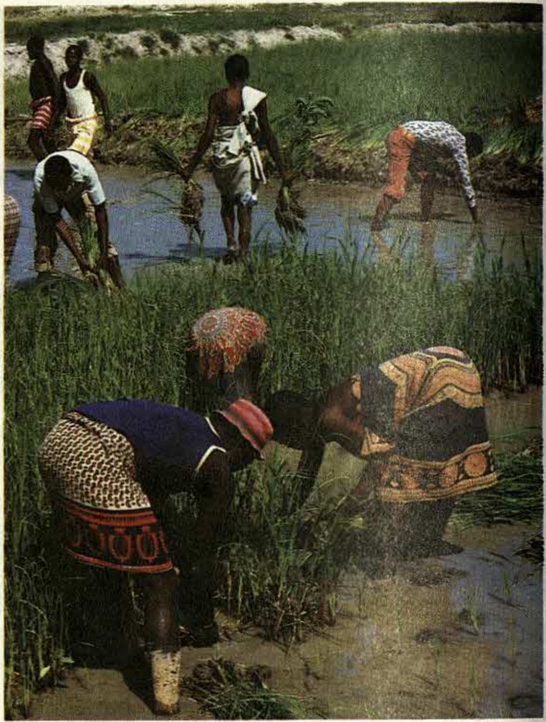
About 98 per cent of Tanzania's people are black Africans. Most of the rest are people descended from Arabs, Europeans, and Asians from India and Pakistan.

The black Africans belong to about 120 ethnic groups, including the Sukuma, Chagga, Makonde, and Nyamwezi peoples. No single group is large enough to control the country, and Tanzania has not suffered the ethnic violence that has troubled other African nations. Tanzania's ethnic balance has helped the government develop a sense of national unity.

Way of life. Most rural Tanzanians farm for a living. Some raise livestock, such as chickens, goats, and sheep. Raising cattle is the chief activity of the Masai and other peoples in the interior of Tanzania. Cows' milk is an important part of their diet. Fishing is an important activity for people who live along the Indian Ocean coast, on the nearby islands, and near inland lakes.

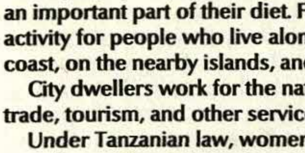
City dwellers work for the national government, or in trade, tourism, and other service industries.

Under Tanzanian law, women have the same rights as men. In practice, however, women still have lesser rights in such areas as education, marriage, and ownership of property. Women are largely responsible for homemaking and raising children. In rural areas, they often perform more farm work than men.

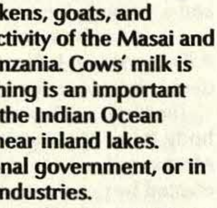


Farmers transplant rice, *above,* near a lake in central Tanzania. Rice ranks among the country's chief food crops. Agriculture employs about 80 per cent of Tanzania's workers.

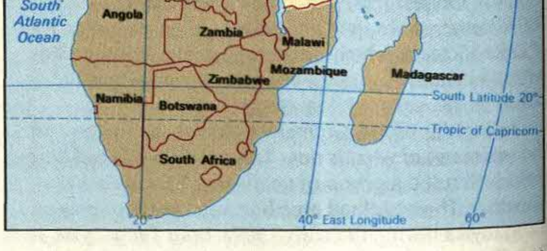
Languages. Swahili and English are the official languages of Tanzania. Swahili, a blend of Arab and African languages, is more commonly used in everyday speech and serves as the national language. Most blacks also speak at least one tribal language. Almost all the tribal



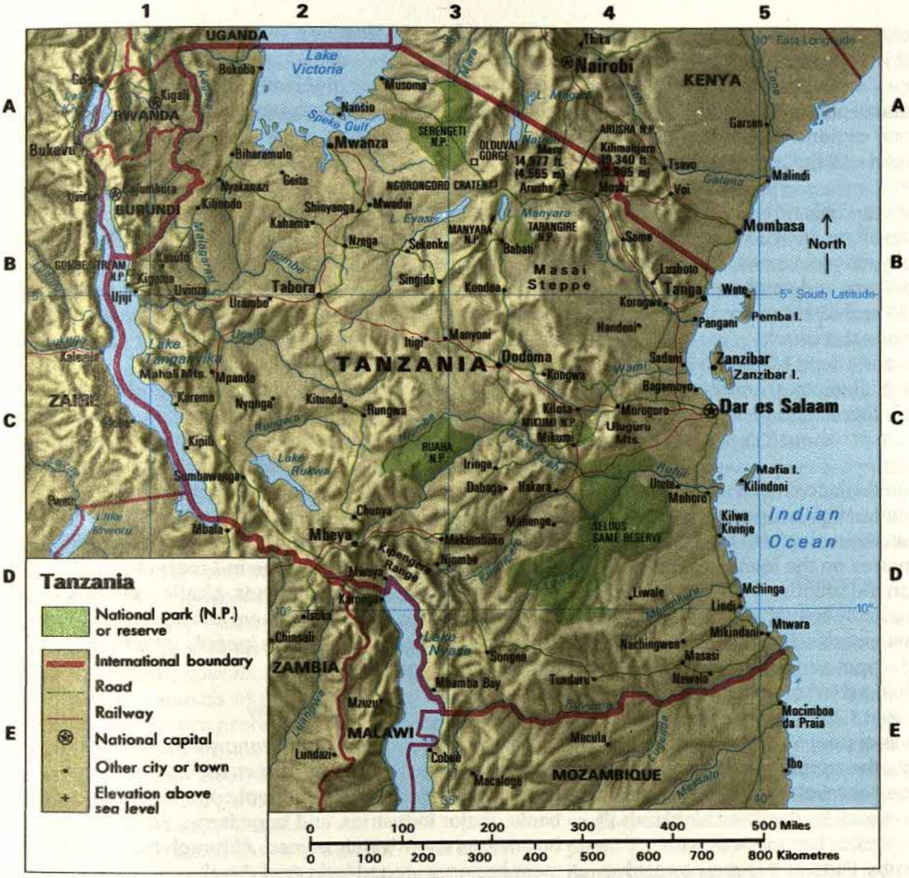
Tanzania's flag was adopted in 1964. The green represents agriculture; the black, the nation's people; the blue, the Indian Ocean; and the gold, mineral resources.



The coat of arms was adopted in 1964. The flaming torch represents freedom and knowledge, and the axe and the hoe stand for agricultural development.



Tanzania is a large country in eastern Africa. It includes several islands near the mainland in the Indian Ocean.



Tanzania map index

Cities

Arusha	55,281	B	4
Dar es Salaam	870,020	C	5
Dodoma	45,703	C	3
Iringa	57,182	C	3
Kigoma	50,044	B	1
Mbeya	76,606	D	2
Morogoro	61,890	C	4
Moshi	52,000	B	4
Mtwara	48,510	D	5
Mwanza	110,611	A	2
Tabora	67,392	B	2
Tanga	103,409	B	5
Zanzibar	110,669	C	5

Source: 1978 census.

Physical features

Arusha National Park	A	4
Gombe Stream National Park	B	1
Great Ruaha River	C	4
Indian Ocean	D	5
Kilimanjaro (mountain)	A	4
Kipengere Range	D	3
Lake Eyasi	B	3
Lake Manyara	B	3
Lake Natron	A	3
Lake Nyasa	D	3
Lake Rukwa	C	2
Lake Tanganyika	C	1
Lake Victoria	A	2
Mahali Mountains	C	1
Manyara National Park	B	3
Masai Steppe	B	4
Mikumi National Park	C	4
Mount Meru	A	4
Olduvai Gorge	A	3
Pangani River	B	4
Pemba Island	B	5
Ruaha National Park	C	3
Rufiji River	C	4
Ruvuma River	E	4
Selous Game Reserve	D	4
Serengeti National Park	A	3
Tarangire National Park	B	4
Uluguru Mountains	C	4
Wami River	C	4
Zanzibar Island	C	5

languages belong to the Bantu language family.

Housing. Most homes are made of wooden frames plastered with mud and include a garden area nearby. Some homes are round with thatched roofs. Others are rectangular with flat mud roofs. Some homes have metal roofs. In urban areas, some homes are made of cement blocks or baked clay bricks.

Clothing in Tanzania is similar to that worn in other parts of eastern Africa. Traditional clothing among the black Africans includes a colourful, wrap-style garment for women, called the *kanga,* and the *kikoi wrap* for men. Many Muslim men wear a flowing white robe called the *kanzu.* Since about 1960, Western-style trousers and shirts for men have become increasingly popular.

Food and drink. Tanzanians prepare a variety of dishes with maize, sorghum, and other grains. One of the most popular meals, called *ugali,* is a porridge made with maize. Fish is an important part of the diet of Tanzanians who live on the islands and along the coast. Bottled beers and soft drinks are popular. The Chagga people produce a well-known beer called *mbege.*

Recreation. The most common forms of recreation in Tanzania include dancing and singing. Many Tanzanians enjoy playing or watching soccer. Several Tanzanians have become world-class long-distance runners.

Religion. About 35 per cent of the population are *Muslims* (followers of Islam). Many of Tanzania's Muslims live on Zanzibar and along the coast. Christians make up about 30 per cent of the population. Most other Tanzanians practise traditional African religions.

Education. Tanzania has one of the highest literacy rates in Africa. About 80 per cent of the adult population of Tanzania can read and write. Although Tanzanian law requires seven years of primary education, only about half of the children go to primary school. Only about 3 per cent attend secondary school. Many children who do not attend school come from poor families and are needed to work on family farm plots. Since the early 1980's, economic problems have caused a shortage of basic school supplies.

The University of Dar es Salaam is Tanzania's chief university. It has about 3,500 students. Many adults attend technical and vocational schools.

Arts. Tanzania's most common artistic expressions include traditional African music and dance. These art forms often tell stories of tribal heroes and local gods. Other notable art forms are associated with various ethnic groups, such as carved figures and masks of the Makonde, carved animal figures of the Zaramo, and leather shields of the Masai.

Land and climate

Tanzania covers about 945,000 square kilometres. Many mountains and Lakes Tanganyika and Nyasa in Tanzania are part of the Great Rift Valley. This valley, which runs north and south through eastern Africa, consists of a series of cracks in the earth that form deep, steep-sided valleys. The valley has branches that extend through central Tanzania and along the country's western border. Tanzania's land regions include (1) the coastal lowlands and islands, (2) the plateaus, and (3) the highlands.

The coastal lowlands and islands. The mainland borders the Indian Ocean along an 800-kilometre coast. The coastal strip has many mangrove swamps and coconut palm groves. The northern and southern lowlands extend inland between 15 and 65 kilometres. The central lowlands extend farther into the country.

Zanzibar, the largest coral island off the African coast, covers about 1,660 square kilometres. Another Tanzanian island, Pemba Island, lies 40 kilometres northeast of Zanzibar Island. Pemba covers about 985 square kilometres.

The coastal lowlands and islands make up the hottest and wettest part of Tanzania. High temperatures average 29° C throughout the year. Annual rainfall totals between about 80 and 140 centimetres on the lowlands and exceeds 100 centimetres on the islands.

The plateaus rise gradually from the coastal lowlands. They include a vast grassland in northeastern Tanzania, called the Masai Steppe, and a grassy central plateau that covers more than a third of the country. The Masai Steppe rises to about 1,100 metres above sea level. It is home to the Masai people, who graze cattle there. West of the steppe, the central plateau reaches about 1,200 metres above sea level. The central section is usually drier than the coastal lowlands or highlands. It is mostly covered by grasses or barren land, with patches of trees and shrubs. Parts of this region receive less than 50 centimetres of rain annually. The plateaus have an average daytime high temperature of 29° C and cool nights.

The highlands. Northern Tanzania has some of the country's highest mountain ranges, which include Kilimanjaro. Several other highlands rise in the central and southern regions. Temperatures in the highlands average about 24° C. Highland regions often receive more than 100 centimetres of rain each year.

Rivers and lakes. The Rufiji is Tanzania's chief river. It flows from the southern highlands and drains much of southern Tanzania. Other major rivers include the Pangani, the Ruvuma, and the Wami. Lake Victoria lies in northern Tanzania and forms part of Tanzania's border with Kenya and Uganda. Lakes Tanganyika and Nyasa lie along Tanzania's western border.

Animal life. Tanzania is famous for its millions of large, wild animals that thrive in vast parklands. In northern Tanzania, the Serengeti National Park covers about 14,500 square kilometres and is noted for its lions and huge herds of antelopes and zebras. In the south, the Selous Game Reserve—the world's largest animal reserve—covers about 54,000 square kilometres. It has about 50,000 elephants—one of the largest populations in Africa. Other animals common in Tanzania include baboons, buffaloes, hippopotamuses, giraffes, monkeys, and rhinoceroses. The government allows limited hunting in some areas. But *poachers* (people who hunt illegally) remain a problem.

Economy

Tanzania has a developing economy based on agriculture. The country follows a socialist economic system, under which the government controls the nation's banks, major industries, and large farms. Some small businesses are privately owned. Although the government has encouraged industrial development, most industries are small and unprofitable. Tanzania depends on hydroelectric plants and imported petroleum to generate electricity.

Zebras and gnus roam across Tarangire National Park, *left,* in northern Tanzania. These animals and other wildlife are protected in Tanzania's many national parks. The country also has many game reserves, where hunting is limited. These parklands cover large areas of Tanzania and include the Serengeti National Park, Ngorongoro Crater, and Selous Game Reserve.

Agriculture. Although only about 5 per cent of Tanzania's land area is used for farming, agriculture accounts for more than a third of the country's economic production. The richest soil lies in the northern and southern highlands and around Lake Victoria.

Most farming is done by hand with hoes and long-bladed knives. Many farmers can grow only enough food to feed themselves and their families. Chief food crops include bananas, cassava, maize, millet, rice, sorghum, wheat, and vegetables. The Masai and some other peoples raise cattle.

Large, government-operated farms produce many of the crops that Tanzania exports. Most of these farms were private plantations under British rule. The major export crops include coffee, cotton, tea, and tobacco. About two-thirds of Tanzania's export earnings come from these crops. Other important crops produced for foreign trade include cashew nuts, cloves, coconuts, *sisal* (a plant used in making rope), and sugar cane.

Service industries, taken together, account for about half the total value of Tanzania's economic production. Government and trade are the leading service industries. Other service industries include banking, education, health care, insurance, and tourism.

The government administers many service industries, including banking, education, insurance, and health care. Most of Tanzania's wholesale and retail trade involves the sale of farm products. Tourism benefits many types of establishments, including hotels, national parks, and restaurants. The chief tourist attractions are the wildlife in the national parks. Many tourists also enjoy the palm-shaded coastal beaches.

Manufacturing contributes about 5 per cent of the country's economic production. Food processing is Tanzania's chief industry. Other important industries produce fertilizer, textiles, and petroleum products. Tanzania also has factories that produce aluminium, cement, paper, sugar, and steel.

Mining accounts for less than 1 per cent of the economic production of Tanzania. Mining operations produce diamonds and other gemstones, coal, and gold.

Foreign trade. Coffee, cotton, tea, and tobacco are Tanzania's main exports. Zanzibar's primary export is cloves. The chief imports include chemicals, construction materials, food, machinery, petroleum and petroleum products, and transportation equipment. Tanzania's main trading partners are Great Britain, Italy, Japan, and Germany.

Tanzanians sell bananas at an open-air market on the island of Zanzibar, *above.* Selling farm products is an important economic activity in Tanzania's cities and towns.

Transportation and communication. Tanzania's large area and poor economic conditions have made development of transportation and communication services difficult. The country has about 80,000 kilometres of roads. But few roads are paved, and most are poorly maintained. Less than 1 per cent of all Tanzanians own a car. Tanzania's main railway links Dar es Salaam with Zambia to the west. Dar es Salaam, which has a fine harbour, is Tanzania's chief port. It handles trade from Burundi, Malawi, Rwanda, Uganda, Zaire, and Zambia. International airports operate at Dar es Salaam, near Arusha, and on Zanzibar.

Three daily newspapers are published in Tanzania—two in Swahili and one in English. The country has two radio stations and an average of 1 radio for every 12 people. Television service is available only on Zanzibar.

History

In Tanzania, scientists have found remains of some of the earliest-known human settlements. Anthropologist Louis Leakey and other members of the Leakey family discovered bones, tools, and other signs of early human life in the Olduvai Gorge area of northern Tanzania. Some remains date back more than 1 million years.

The prehistoric human beings who lived in what is now Tanzania were hunters and gatherers. They lived in small groups, catching animals and collecting wild plants for food. By about A.D. 500, people who spoke Bantu languages had migrated from the north and from central Africa to eastern Africa.

The development of trade. Arab traders from the Middle East began to settle along the coast of eastern Africa during the 1100's. These traders often married African women. These Arab-African families and their settlements produced the Swahili culture. Major trading centres developed on Zanzibar and other islands.

In the early 1500's, Portuguese traders gained control of Africa's east coast. Local rebellions helped push out the Portuguese in the late 1600's. In 1698, Arabs from Oman, a country on the Arabian Peninsula, took control of Zanzibar and developed trade on the mainland. By this time, the Nyamwezi and Yao ethnic groups had become active in long-distance trade. Their caravans brought gold, ivory, and slaves from the interior to the coast, where they exchanged them for such items as cloth, glassware, and ceramics from Asia.

The Arabs also developed the slave trade. From the mid-1700's to the late 1800's, the Arabs sold thousands of black Africans from the mainland into slavery. Zanzibar was a major slave market. The slave trade caused much conflict and broke up many African communities.

German and British rule. During the 1800's, explorers and Christian missionaries from Europe travelled deep into the mainland of what is now Tanzania. European nations increasingly competed for control of African territory. In the 1880's, Germany took control of the present-day mainland of Tanzania. The Germans forced many Africans to work on plantations. This action contributed to a major uprising in 1905 called the Maji Maji rebellion. German forces killed many thousands of Africans before putting down the revolt.

The United Kingdom (UK) made Zanzibar and Pemba islands a British protectorate in 1890. The UK gradually took over the powers of the Omani sultans in local affairs. After Germany's defeat in World War I (1914-1918), the UK gained control over the mainland and named it Tanganyika. During this period, people from other parts of the British Empire and Europe began to settle in Tanganyika. These immigrants included thousands of Indians, who worked as merchants and traders.

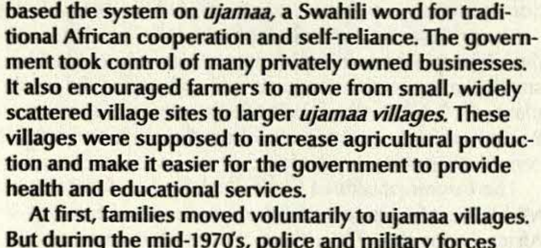
Independence. In 1946, Tanganyika became a United Nations trust territory. The United Kingdom had the responsibility of preparing it for independence.

In Tanganyika, the UK sought to create a political system with equal representation of Europeans, Asians, and Africans. The Africans argued that such a system denied them their rights as the vast majority. In 1954, the Africans formed the Tanganyika African National Union (TANU). Led by Julius Nyerere and others, TANU won independence with majority rule for Tanganyika in 1961. The next year, Nyerere was elected president. The UK granted Zanzibar independence in 1963.

The united republic. Tanganyika and Zanzibar joined together in April 1964 and adopted the name of the United Republic of Tanzania in October. Nyerere became the country's first president. Under his direction, Tanzania adopted a socialist economic system. Nyerere based the system on *ujamaa,* a Swahili word for traditional African cooperation and self-reliance. The government took control of many privately owned businesses. It also encouraged farmers to move from small, widely scattered village sites to larger *ujamaa villages.* These villages were supposed to increase agricultural production and make it easier for the government to provide health and educational services.

At first, families moved voluntarily to ujamaa villages. But during the mid-1970's, police and military forces forced about 5 million others to move. Many farmers disliked the ujamaa villages, which were far from the farmers' plots of land in their former villages.

In foreign affairs, Nyerere worked to increase regional cooperation. In 1967, Tanzania, Kenya, and Uganda formed the East African Community. This organization promoted trade and coordinated economic development between the countries. In 1977, however, the East African Community fell apart. The collapse occurred largely because of Kenya's emphasis on private enterprise and Tanzania's commitment to socialism. In addition, Uganda was ruled by a brutal dictator, Idi Amin Dada. Amin's government, which killed thousands of Ugandans, sent troops that invaded Tanzania in 1978. Tanzanian forces soon beat back the invaders and helped Ugandan rebels overthrow Amin. The war was a moral and military triumph for Tanzania. But it cost over 500 million U.S. dollars at a time when the country's economy was suffering from the high price of imported oil.



The Palace of Wonders on Zanzibar, *above,* was home to many Arab *sultans* (rulers). The Arabs developed Zanzibar into a trading centre in the 1700's and governed the island until 1964.

Recent developments. During the 1980's, growing trade deficits and debt contributed to an economic collapse. The economic hard times forced Tanzania to alter its socialist system. The government decreased its control of the economy and opened more areas to private businesses. This programme included the firing of thousands of government employees and the reduction of state-owned operations. Some improvements occurred, but the economy still faced serious difficulties.

In 1985, Nyerere retired as president. In 1990, he retired as CCM chairman. But he remains a major influence in Tanzania. Ali Hassan Mwinyi, the president of Zanzibar, succeeded Nyerere as president and as CCM chairman. Mwinyi continued to work for less state control of the economy. In 1993, a special congress of the CCM voted in favour of a proposal to end one-party rule.

Related articles in ***World Book*** include:

Dodoma
Kilimanjaro
Lake Tanganyika
Lake Victoria
Leakey family
Nyerere, Julius K.
Races, Human (picture: African)
Zanzibar

Outline

I. Government
- A. National government
- B. Regional and local government
- C. Politics
- D. Courts
- E. Armed forces

II. People
- A. Population and ancestry
- B. Way of life
- C. Languages
- D. Housing
- E. Clothing
- F. Food and drink
- G. Recreation
- H. Religion
- I. Education
- J. Arts

III. Land and climate
- A. The coastal lowlands and islands
- B. The plateaus
- C. The highlands
- D. Rivers and lakes
- E. Animal life

IV. Economy
- A. Agriculture
- B. Service industries
- C. Manufacturing
- D. Mining
- E. Foreign trade
- F. Transportation and communication

V. History

Questions

What two former UK colonies united in 1964 to form Tanzania?
What are Tanzania's chief exports?
What led to the collapse of the East African Community in 1977?
Who was the first president of Tanzania?
What are Tanzania's *ujamaa villages*?
Where is most of Tanzania's fertile land?
Which European countries ruled what is now Tanzania during the late 1800's and early 1900's?
How did the slave trade affect Tanzanian communities?
What is the national language of Tanzania?

Tanzanite is a semiprecious gemstone. It is a variety of a mineral called *zoisite.* Tanzanite crystals are *trichroic* (three-coloured). As the gemstone is turned, its colour changes from deep blue to purple to yellowish-green.

When heat is applied to tanzanite crystals, they become uniformly blue. The blue colour is most popular, so the majority of tanzanite is heat-treated. Tanzanite is cut into gemstones with numerous *facets* (flat, polished surfaces), which emphasize its light-reflecting quality. The gemstones are used in such jewellery as rings, earrings, and pendants.

Tanzanite was discovered in 1967 in Tanzania, after which it was named. Tanzania is the only known source of tanzanite. Because the supply is limited, the gemstones are expensive.

Tao Te Ching. See **Taoism; Laozi.**

Taoiseach. See **Ireland, Government of.**

Taoism is a philosophy that began in China, probably during the 300's B.C. Taoism is also the name of a religion that began in about the 100's B.C. Through the centuries, the philosophy has influenced artists and writers in the East and West. The word *tao* (also spelled *dao*) originally meant *road* or *way.* The Tao (Way) represents the characteristics or behaviour that makes each thing in the universe what it is. The word is also used to mean reality as a whole, which consists of all the individual "ways."

Taoism as a philosophy. The beliefs of Taoism as a philosophy appear in two books, the *Laozi* (later renamed the *Tao Te Ching, The Classic of the Way and the Virtue*) and the *Chuang-tzu.* The Laozi, also spelled *Lao-tzu,* is a collection from several sources and its authors and editors are unknown. The ideas were partly a reaction against *Confucianism,* a philosophy that developed in China beginning in about 500 B.C.

According to Confucianism, people can live a good life only in a well-disciplined society that stresses attention to ceremony, duty, morality, and public service. The Taoist ideal, on the other hand, is a person who avoids conventional social obligations and leads a simple, spontaneous, and meditative life close to nature.

Taoist philosophy had a great influence on Chinese literature and art. For example, the poetry of Tao Qian (T'ao Ch'ien) (A.D. 365?-472?) expresses a distaste for worldly affairs and a yearning for a life in harmony with nature. During the early 1200's, Xia Gui (Hsia Kuei) painted landscapes that reflect the Taoist sensitivity to nature.

Taoism as a religion was influenced by Chinese folk religion. In folk religion, most of the gods are human beings who displayed exceptional powers during their lifetimes. For example, Guan Di, who is the protector of business people, lived as a general during the A.D. 200's.

A symbol of Taoism stands for what Taoists believe are the two basic forces in the universe—*yin* (female) and *yang* (male). The black shape in the centre and the broken lines represent yin. The centre red shape and the solid lines symbolize yang.

Taoism has a hereditary priesthood. The priests conduct public rituals, during which they submit the people's prayers to the gods of folk religion. The chief priest, who is in a trance, prays to other divinities on behalf of the worshippers. These divinities are not former human beings but represent aspects of the Tao.

The members of some Taoist groups have sought to attain immortality through magic, meditation, special diets, breath control, or the recitation of scriptures. The Taoist search for knowledge of nature has led many believers to pursue various sciences, such as alchemy, astronomy, and medicine.

See also **Confucianism; Laozi; Religion** (Taoism; picture: Taoist deities); **Zhuangzi.**

Tap. See **Plumbing.**

Tap-dancing. See **Dancing** (The rise of romanticism).

Tape recorder is a device for recording sound, pictures, and various kinds of information on magnetic tape. It can also play back tape recordings. Tape recorders are widely used by the recording industry and in radio and television broadcasting. Millions of people enjoy listening to music on tape recorders in their homes and cars. Tape recordings of books, called *talking books,* are made especially for the blind. Tape recorders can also be used to record computer data, dictation, readings from scientific instruments, and signals that activate automated equipment.

Tape recordings have several advantages over records. They can be played back immediately after being made, and the same tape can be used to record many times by erasing the previous recording. Tape recordings can easily be edited by cutting out the unwanted sections and then joining the ends of the tape. Tapes are also more durable than records.

Tape recorders are commonly used to record sound, and this article deals with audio tape recorders. For information on tape recorders that record visual images as well as sound, see the article on **Videotape recorder.**

Audio recording tape is a thin plastic ribbon coated on one side with particles of a substance that can be easily magnetized, such as iron oxide or chromium dioxide. A tape recorder receives sounds in the form of electric signals, which it converts into a changing magnetic field. During recording, the field magnetizes the particles on the tape into patterns. When the tape is played back, the magnetic patterns generate electric signals to reproduce the original sound. Tape recording can be accomplished by two different processes: *analogue recording* and *digital recording.*

In analogue recording, the patterns of the electric signals are *analogous* (similar) to those of the magnetic signals. Analogue tape recordings store a signal in a wave form that looks like the wave form of the original sound. In a digital recording, the electric signals are converted to a *digital* (numerical) code for storage on the tape. This code represents the sound. Digital recording produces better sound quality with less background noise and distortion than analogue recording does. Digital technology is also used in compact discs (CD's).

Digital audiotape (DAT) can be damaged more easily than analogue audiotape and so must be carefully handled and stored. Analogue tape needs a thicker magnetic coating than DAT does to store a range of electric signals.

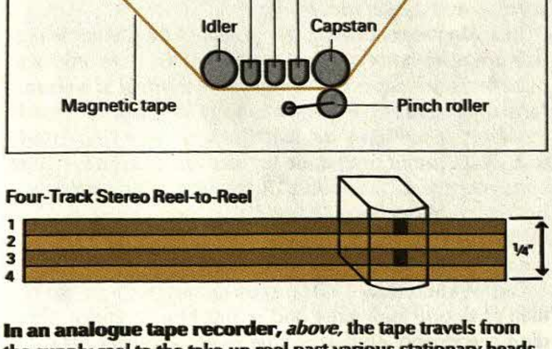
Audio tape recorders include the open-reel model, *left,* the portable cassette player, *centre,* and the cassette deck, *right.* Open-reel recorders generally produce better sound quality and are used in recording studios. Cassette models are more compact and easier to operate.

The quality of the magnetic coating, rather than its thickness, affects DAT sound quality.

How tape recorders work

Most audiotape recorders operate in a similar way, whether they are analogue or digital. They have two reels—a full *supply reel* of magnetic tape and an empty *take-up reel.* One end of the tape from the supply reel is attached to the take-up reel. Between the two reels, a soft rubber *pinch roller* presses the tape tightly against a metal rod called a *capstan.* When the tape recorder is switched on, a motor turns the capstan. As the capstan turns, it pulls tape from the supply reel. At the same time, the take-up reel pulls gently on the tape to wind it up.

Before the tape reaches the capstan, it passes the *heads* of the tape recorder. The heads are small electromagnets that erase, record, and play back. The speed at which the tape moves past the heads depends on the type of tape recorder. The speeds are measured in *inches per second* (*ips*). The most commonly used speeds are $1\frac{7}{8}$, $3\frac{3}{4}$, $7\frac{1}{2}$, and 15 ips (4.8, 9.5, 19, and 38 centimetres per second). The higher speeds produce recordings of the best quality, but recording at slower speeds adds to the playing time of the tape.



In an analogue tape recorder, *above,* the tape travels from the supply reel to the take-up reel past various stationary heads. Each side of the tape holds two tracks that run the length of the tape. Some digital recorders also have stationary heads.

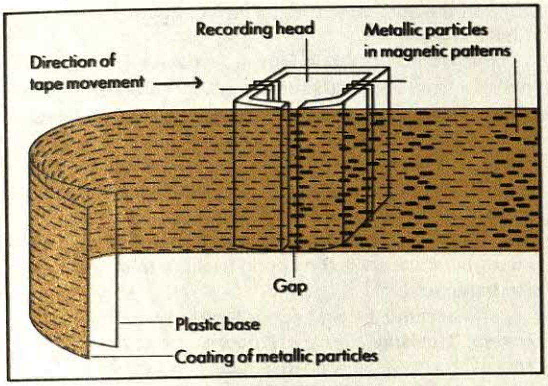
Erasing and recording. When an analogue tape recording is made, the tape first comes into contact with the *erase head.* The erase head, which is automatically activated during recording, produces a strong magnetic field that removes any previous recording from the tape. The blank tape then moves past the *recording head.*

The sounds to be recorded on the tape are converted into an electric current by a microphone (see Microphone). An *amplifier* strengthens the current, which is then fed into the recording head. As the current flows through the head, it sets up a changing magnetic field around a small gap in the electromagnet. When the tape passes the gap, the magnetic field magnetizes the magnetic particles on the tape into a pattern like that of the sound waves entering the microphone.

Unlike analogue recorders, most DAT recorders have no erase head. Instead of erasing the tape first, they use a process called *overwriting* to record new sound. Recording and playback heads may be either stationary or rotating. Stationary heads are like the heads on an analogue tape recorder. In a rotating system, two heads are mounted opposite one another on a rotating cylinder called a *drum.* During recording and playback, the tape moves past the spinning drum.

A DAT recorder converts the original electric signals to digital information in several steps. First, the signal is filtered to prevent interference from unwanted high frequencies. Next, each second of sound is broken up into 48,000 segments called *samples.* Each sample is given a numerical code. This code is recorded on the tape in the form of magnetic patterns.

Different kinds of tape recorders use different widths of magnetic tape. Most tape recorders can record more that one *track* (separate recording) on a tape. To produce stereophonic sound, a tape recorder must be able

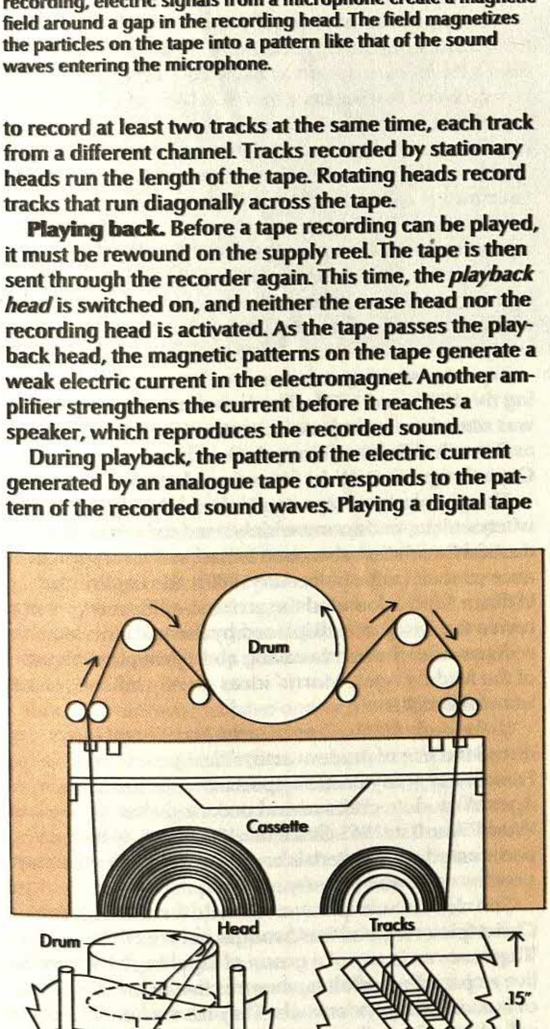

Recording head
Metallic particles in magnetic patterns
Direction of tape movement
Gap
Plastic base
Coating of metallic particles

The recording process. Recording tape consists of a plastic base coated with metallic particles that are easily magnetized. In recording, electric signals from a microphone create a magnetic field around a gap in the recording head. The field magnetizes the particles on the tape into a pattern like that of the sound waves entering the microphone.

to record at least two tracks at the same time, each track from a different channel. Tracks recorded by stationary heads run the length of the tape. Rotating heads record tracks that run diagonally across the tape.

Playing back. Before a tape recording can be played, it must be rewound on the supply reel. The tape is then sent through the recorder again. This time, the *playback head* is switched on, and neither the erase head nor the recording head is activated. As the tape passes the playback head, the magnetic patterns on the tape generate a weak electric current in the electromagnet. Another amplifier strengthens the current before it reaches a speaker, which reproduces the recorded sound.

During playback, the pattern of the electric current generated by an analogue tape corresponds to the pattern of the recorded sound waves. Playing a digital tape produces electric currents that carry a numerical code. DAT recorders convert this code to electric signals, which an amplifier strengthens and sends to the speakers.



In a DAT recorder, like the cassette model with a rotary head above, the tape travels on an angle past a rapidly spinning drum. Two heads are placed on opposite sides of the drum. The tracks are laid diagonally across the tape.

Kinds of tape recorders

There are two main kinds of audio tape recorders: open-reel and cassette.

Open-reel tape recorders are used by recording studios and broadcasting stations. They produce better-quality sound than do cassette recorders. To use an open-reel recorder, the operator places a supply reel and a take-up reel on spindles on the outside of the recorder. The tape is threaded by hand past the heads of the recorder and through the capstan and pinch roller.

Open-reel recorders for home use run at $3\frac{3}{4}$ and $7\frac{1}{2}$ ips. Most home models record one, two, or four tracks on $\frac{1}{4}$-inch (6 millimetres) tape. Recording studios operate recorders at 15 ips or 30 ips (38 or 76 centimetres per second). Many professional recorders use 2-inch (5.1 centimetres) tape, which can carry as many as 24 tracks.

Cassette tape recorders are widely used in homes and cars. Portable cassette recorders are also popular. Cassette recorders are in most ways small copies of open-reel recorders. But cassette recorders are easier to operate because the tape does not have to be threaded through them. A cassette recorder uses a small plastic case, called a *cassette,* which encloses a miniature supply reel and take-up reel. The cassette is snapped into the recorder and is ready to use. Part of one edge of the cassette is cut out to enable the tape to come into contact with the heads and capstan.

Cassette tape measures only 0.15-inch (3.8 millimetres) wide. Analogue cassette tape carries four tracks, two on each side. A digital cassette is about half the size of an analogue cassette, but it has a longer playing time. It uses two tracks and is played on only one side. Analogue cassette recorders operate at $1\frac{7}{8}$ ips and digital cassette recorders at $\frac{1}{3}$ ips or $\frac{1}{2}$ ips.

History

In 1898, Valdemar Poulsen, a Danish engineer, invented the first machine for recording sound magnetically. He called his invention the *telegraphone.* It used an electromagnet to make a magnetic recording on steel wire. However, gramophone recordings were more popular at that time, and little use was made of magnetic recording for a number of years.

A small number of audio recorders began to be produced commercially in the early 1930's. Initially, steel wire and steel ribbon were the only recording materials used. But they were awkward to handle and store and nearly impossible to edit. During World War II (1939-1945), German engineers perfected the *magnetophon,* which was the first recorder to use plastic magnetic tape.

By 1950, tape recorders were being widely used in the radio and recording industries. Manufacturers began to produce stereo tape recorders for use in the home in the mid-1950's. Cartridge tape systems were introduced in 1958, and, in the mid-1960's, cassettes revolutionized the tape recorder market.

Since the late 1960's, the sound quality of audio recorders has been steadily improving. Many recorders are now equipped with electronic noise reduction systems that reduce the faint hissing sound made by tape. Chromium dioxide and other new tape coatings have improved the recording capability of cassette tapes. Manufacturers introduced digital recording systems in the 1970's.

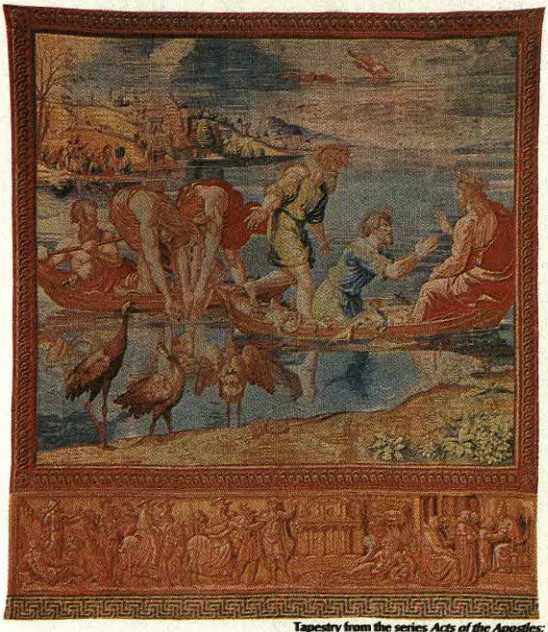
See also **Electromagnet; Headphones; High-fidelity system; Record player; Speaker; Videotape recorder.**

Tapestry is a woven fabric made from threads of different colours to form a picture or design. Most tapestries serve as indoor wallhangings.

How tapestries are made. Tapestries are woven on a loom. Like other woven fabrics, tapestries consist of vertical threads, which make up the *warp,* and horizontal threads, which form the *weft.* A tapestry weaver winds the threads of the weft over and under the threads of the warp, which are attached to the loom. In ordinary woven cloth, the warp and the weft can both be seen. But in the tapestry technique, the weft completely covers the warp. The weaver achieves this effect by packing the threads of each newly completed row against the previous row with a comblike tool called a *reed.*

A tapestry weaver works from the back of the tapestry and follows a pattern called the *cartoon,* which indicates the design and thread colours. When the tapestry is finished, its design is the reverse of the cartoon. Linen and wool have been the most common materials, along with gold and silver thread.

History. Tapestry is one of the oldest techniques in textile art. It probably originated in prehistoric times, but the oldest surviving cloth fragments and written accounts date from about 1500 B.C. They come from many parts of the ancient world, including Egypt, Babylonia, China, and Peru.



Tapestry from the series *Acts of the Apostles;* Pinacoteca, The Vatican, Rome

An Italian tapestry called *The Miraculous Draught of Fishes* was designed by the Renaissance artist Raphael. It was woven in about 1519 by Pieter van Aelst, a Flemish craftsman. The scene, based on an episode in the New Testament, shows Peter kneeling before Jesus, *right,* in a boat on the Sea of Galilee.

Tapestry flourished in Europe in the Middle Ages, especially from the 1300's to the 1500's. Professional workshops produced sets for castles and churches. Most weavers worked from a full-scale cartoon painted by another artist. Because most tapestries were woven in wool, they helped insulate rooms as well as decorate them. Kings and nobles took tapestries with them when they travelled to create attractive and familiar surroundings, and sometimes they hung them in their tents on the battlefield.

Paris became the first major tapestry-making centre in Europe. The *Apocalypse of Angers,* one of the oldest sets of tapestries in existence, was produced there during the 1370's or 1380's. During the 1400's, Arras in France, and Brussels and Tournai in Belgium, became famous tapestry-making centres.

Most tapestries from the Middle Ages depict scenes from history, mythology, the Bible, or daily life. Many have a *millefleurs* design as background. Millefleurs is a French word that means *a thousand flowers.* The design consists of flowers and leaves in realistic detail scattered over a background, making the picture seem flat like the wall it decorates. One famous set of millefleurs tapestries is called *The Lady and the Unicorn.*

In the early 1500's, the Italian painter Raphael designed cartoons for a set of tapestries called the *Acts of the Apostles.* The tapestries looked like paintings with figures standing in a three-dimensional space. Their realistic compositions greatly influenced future tapestry design.

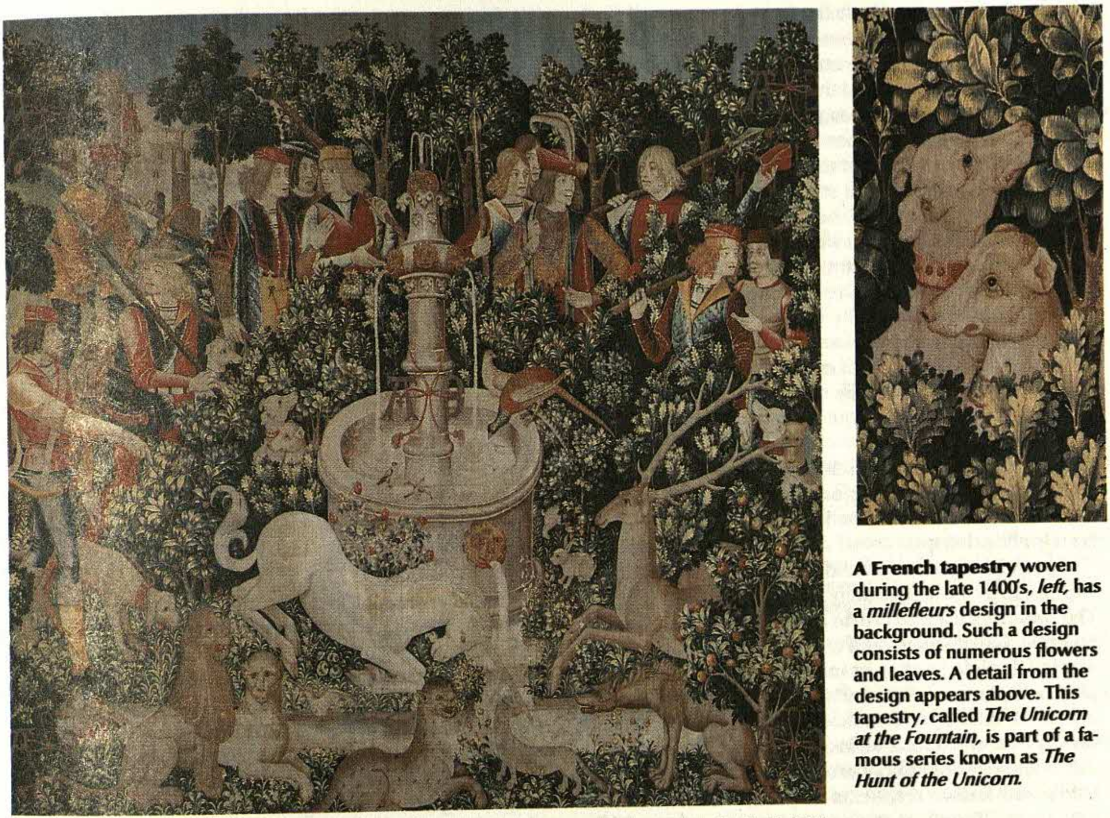
Tapestry weaving continued to thrive in Europe during the 1600's and 1700's. The Gobelin factory in Paris was one of the most famous centres. Such famous artists as Peter Paul Rubens, François Boucher, and Francisco Goya designed cartoons for various factories.

The popularity of tapestry declined during the 1800's, when wallpaper became widely used in homes. The Industrial Revolution also contributed to the disappearance of such crafts. In the late 1800's, the Englishman William Morris founded the arts and crafts movement to revive the handcrafts displaced by the machine. He also rediscovered the handweaving and dyeing techniques of the Middle Ages. Morris' ideas greatly influenced artists of the 1900's.

In the early 1900's, French artist Jean Lurçat introduced the use of modern artists' designs at Aubusson, France, a tapestry centre important since the Middle Ages. A modern crafts revival occurred after the end of World War II in 1945. Since the 1950's, artists have experimented with materials and weaving to create many new forms of wall tapestry.

See also **Animal** (picture: Animals that hunt); **Jesus Christ** (picture: Jesus was brought before Pilate).

Tapeworm is any of a group of tapelike flatworms that live as parasites. Adult tapeworms live in the intestines of human beings or animals. They have a headlike organ called a *scolex* and a series of blocklike segments in a flat body. A tapeworm has no mouth or intestine. It absorbs food through its body wall. Some tapeworms measure less than 2.5 centimetres long and have only a few segments. Others grow more than 9 metres long and have thousands of segments.



A French tapestry woven during the late 1400's, *left,* has a *millefleurs* design in the background. Such a design consists of numerous flowers and leaves. A detail from the design appears above. This tapestry, called *The Unicorn at the Fountain,* is part of a famous series known as *The Hunt of the Unicorn.*

The Metropolitan Museum of Art, New York City

A tapeworm's scolex has suckers or hooks or both. The worm uses the scolex to attach itself to the intestine of the *host*–that is, the animal in which the worm lives. The rest of the worm's body grows from a necklike region behind the scolex. Numerous segments develop as the worm grows longer. Each segment contains male and female reproductive organs and produces many eggs. Segments filled with eggs may drop off the end of the worm's body. The segments then may pass out of the host's body with body wastes and release the eggs outside the host.

Almost all tapeworms have one or more *larval* (immature) stages and develop in two or three hosts. A newly hatched tapeworm is called an *oncosphere.* It is round and has small hooks. An oncosphere develops in a host that eats it or the egg it hatches from. The oncosphere burrows through the intestine of this host to muscles or other organs. If another animal eats this host, the oncosphere may develop into another larval stage or into an adult tapeworm. A person may be infected by a tapeworm by eating improperly cooked fish, pork, or beef that contains tapeworm larvae.

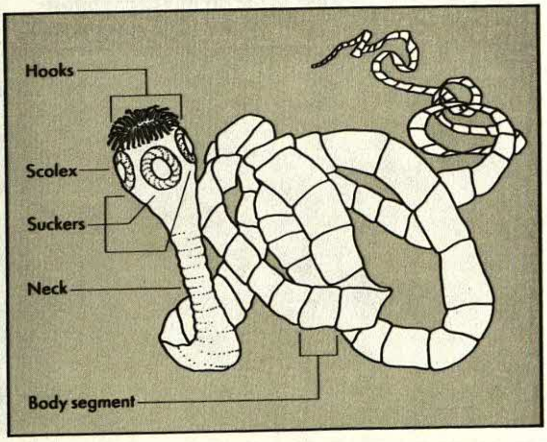
Most adult tapeworms produce no bad effects in people. Sometimes they cause loss of appetite, abdominal discomfort, diarrhoea, nausea, weakness, or anaemia. Tapeworm larvae are much more dangerous to people. A person who accidentally eats eggs of the pork tapeworm may have young worms develop in almost every organ of the body, including the eyes, brain, and heart.

Scientific classification. Tapeworms belong to the class Cestoda of the phylum Platyhelminthes.

See also **Flatworm.**

Tapioca is a food starch that is widely used in making puddings. It is taken from the root of the cassava, a tropical plant of the same family as the castor bean. Tapioca pudding is healthful and easily digested.

Commercial tapioca comes chiefly from Brazil, Java,



A pork tapeworm has a flat, ribbonlike body. Its headlike scolex has both hooks and suckers, which the worm uses to attach itself to the intestines of people and animals.

and the Malay Peninsula. A single plant may yield up 5 kilograms of starch. The roots are 5 to 20 centimetres thick, and 30 to 120 centimetres long. They are washed to remove the prussic acid they contain, and then reduced to a pulp. The pulp is strained until all the starchy particles are separated from the root fibres. The moist starchy pellets are then set on hot iron plates and left to dry. During the drying, the starch pellets form the small, uneven, milky white balls known as *pearl tapioca.* Pearl tapioca must be soaked in water for an hour before it can be cooked. A finer granular form, called *quick-cooking tapioca,* does not require soaking before cooking.

Tapioca swells and thickens the liquid in which it is cooked. A flour made from cassava root is also used as a thickening. This flour is one of the starches called *arrowroot.*

See also **Cassava.**

Tapiola, a community in the city of Espoo, Finland, became world famous as a model for city planning. It lies in southern Finland. For the location of Espoo, see **Finland** (political map).

A private organization and its sponsors founded Tapiola as a new community, or *new town,* in the 1950's. The founders tried to create a community that blends completely with its natural surroundings. They also wanted Tapiola to offer its inhabitants many types of employment, housing, and services so the community would be entirely self-sufficient. Tapiola features a wide variety of architectural styles, and many walking paths that enable people to get around by foot. Some of Finland's best-known architects helped plan the community. Today, Tapiola is the largest business centre of Espoo. But it does not yet provide jobs for all its inhabitants. Many of its approximately 35,000 people work nearby, especially in Helsinki.

See also **Town planning** (picture: Tapiola, Finland); **Finland** (picture: The new town of Tapiola).

Tapir is related to the horse and rhinoceros, though it looks more like a pig. The tapir has a short, heavy body, and a thick neck. Its nose is drawn out to form a movable, short trunk. Its front feet have four toes, and the hind feet have three toes. The tail is short. Tapirs are wary creatures. They live in the depths of the forests, and near water, in which they love to swim. Tapirs feed on the twigs and foliage of trees and shrubs, and on fruit and other vegetable food.

The tapir resembles a pig but actually is related to the horse and rhinoceros. Tapirs have a sturdy body and a short movable trunk. They eat fruit, vegetables, and foliage.

There are two kinds of tapirs that live in South America. The most common one is found in the forest regions east of the Andes. The other makes its home high in these mountains. The two species of tapirs that live in Central America are the smallest of the family. All full-grown American tapirs are of a uniform dark-brown colour, but young American tapirs are marked with yellowish streaks.

The Malayan tapir is found in Sumatra and the Malay Peninsula. It stands 90 to 110 centimetres high at the shoulder. The back, rump, and sides are white while the rest of the thinly haired body is glossy black or dark brown.

People hunt tapirs for their flesh and thick hides. As a result of both hunting and the cutting of forests, tapirs have become rare in many areas.

Scientific classification. Tapirs form the tapir family, Tapiridae. The South American tapir is *Tapirus terrestris.* The mountain tapir is *T. roulini.* The Central American tapir is *T. bairdi.* The Malayan tapir is *T. indicus.*

See also **Animal** (picture: Animals of the tropical forests); **South America** (Animals).

Tar is any of a group of thick, oily, dark-brown or black liquids. Most tars are by-products of the conversion of such organic matter as coal, petroleum, or wood into useful industrial products.

Coal tar, also called *high-temperature coke-oven tar,* is the most important industrial tar. It is condensed from vapours given off during the manufacture of coke from bituminous coal (see **Coke**). This tar is used as a raw material for such products as disinfectants, dyes, perfumes, plastics, roofing and water-proofing materials, and synthetic drugs. See **Coal tar.**

Coal gasifier tar is a by-product of certain manufacturing processes that convert coal into a high-energy gas. This gas can be used as a substitute for natural gas. Coal gasifier tar is a source of various organic chemicals.

Wood tar is a by-product of the *destructive distillation* of wood in the production of charcoal (see **Distillation** [Destructive distillation]). The tar is condensed from vapours given off during the process. It is an important source of acetic acid, methyl alcohol, pine oil, and turpentine.

Oil-gas tar and water-gas tar were once widely used in the manufacture of road-paving materials, wood preservatives, and other products. These tars are by-products of the conversion of petroleum oils into gas used for heating and lighting. They are seldom produced today because other sources supply energy for those purposes.

See also **Pitch.**

Tar sands. See **Bituminous sands.**

Tarabulus. See **Tripoli.**

Tarantella is a popular folk dance that originated in southern Italy. It is a brisk and energetic dance performed in accelerating $\frac{6}{8}$ time. It usually is danced by couples, and it most often is accompanied by music featuring castanets and tambourines. The steps of the dance can be done in a variety of sequences. In some steps, the dancer moves forward and backward while

Dancers in southern Italy perform the tarantella, a lively folk dance. The girls add to the music by beating on tambourines as they kneel in front of their partners.

hopping on one foot. Other steps feature heel-toe movements across the standing foot. The steps are linked by runs, skips, and movements with a partner.

The tarantella gets its name from the city of Taranto. According to folklore, the people there danced the tarantella as a cure for the bite of the tarantula spider. The tarantella is featured in the ballroom scene of the ballet *Swan Lake.*

Tarantula is the common name of any one of a group of mostly large, hairy spiders. Tarantulas are found in warm climates such as those of the Southern and Western United States, and throughout the tropics. Some tarantulas live more than 20 years. Tarantulas get their name from a large wolf spider found around Taranto in southern Italy. People once believed this spider's bite caused a disease called *tarantism.* The victims supposedly leaped in the air and ran about making strange noises. According to superstition, the best cure was a lively Italian folk dance that became known as the *tarantella.*

The tarantula has a hairy body and looks fierce, but its bite is usually no more dangerous than that of other spiders.

One of the world's largest spiders, the *bird spider* of South America, is a tarantula. The bird spider has a body from about 7.5 to 9 centimetres long and can spread its legs about 18 centimetres. Some bird spiders live in trees and eat small birds. Some tarantulas in Brazil eat small reptiles and amphibians. An Australian species, which belongs to a group of tarantulas called *funnel webs,* is more feared than the black widow spider. The *trap-door spider* is a type of tarantula found in warm parts of the world.

Tarantulas found in the United States are quiet creatures that live in burrows. Their bite is no more dangerous to people than the sting of a bee. Their chief means of defence consists of thousands of microscopic, irritating body hairs that can be flung into the air by rubbing motions of the hind legs. The bite of some South American tarantulas may be serious.

Scientific classification. Tarantulas make up the suborder Orthognatha. Bird spiders form the bird spider family, Theraphosidae. Australian funnel web spiders belong to the genus *Atrax.* Trap-door spiders belong to the family Ctenizidae.

See also **Funnel web spider; Spider** (Tarantulas; pictures); **Trap-door spider.**

Tarawa (pop. 24,598), is the capital of Kiribati, a country of many small islands in the southwest Pacific Ocean. Tarawa is an *atoll* (ring-shaped reef) composed of many coral islets that cover a total of 23 square kilometres.

The commercial and shipping centre of Kiribati is Betio, a densely populated islet in the southwest area of Tarawa. Bairiki, east of Betio, is the government centre. Bonriki, in the southeast, has an international airport.

In 1788, the British explorer Captain Thomas Gilbert became the first European to sight Tarawa. The British took control of Tarawa in the 1890's. In 1942, during World War II, Japanese troops seized the atoll. American forces captured Tarawa from the Japanese in 1943 in one of the bloodiest battles of the war. Britain then ruled Tarawa until 1979, when it became part of the independent nation of Kiribati.

See also **Kiribati; World War II** (Island hopping).

Taree (pop. 40,513) is the chief town of the Manning River district, a prosperous dairy-farming and crop-farming area in eastern New South Wales, Australia. The town is almost 325 kilometres northeast of Sydney. It is located in the centre of a tourist resort area that includes attractions such as the Ellenborough Falls, a spectacular waterfall. Taree is noted for its water sports carnival, which is held each January on the Manning River. Taree's name is an abbreviation of the Aboriginal word *tareebit* (fruit of the wild fig).

Targum. See **Bible** (The first translations).

Tariff is a tax placed on goods that one nation imports from another. Many nations use tariffs to protect their industries from foreign competition. Tariffs provide protection by acting to raise the price of imported goods. Thus, tariffs encourage domestic firms to increase their production, and consumers are forced to pay higher prices for the protected goods. Tariffs on exports are sometimes used in some countries to raise revenue. A nation may also use tariffs to influence, or protest against, political or economic policies of other countries.

Nations set their tariff rates in various ways. They may have commercial treaties that include a *most-favoured-nation* (MFN) clause. Under an MFN clause, each nation's lowest regular tariff rates apply to all countries that sign the treaty. *Preferential tariffs,* which are lower than MFN tariffs, may be applied to favour imports from less developed countries. Nations that form a *customs union* eliminate tariffs on trade among themselves. These nations also have a common set of tariffs that cover their trade with nonmember countries. A *common market* has the same tariff policies as a customs union but provides for greater economic cooperation among its members. Nations that form a *free trade area* have no tariffs among themselves, but each member may set its own tariffs on goods produced by nonmembers.

Main kinds of tariffs

Tariffs may be classified according to their purpose. Tariffs levied to restrict imports are called *protective tariffs.* Those levied to increase government revenue are known as *revenue tariffs.* Many governments used revenue tariffs in the past. But today these tariffs are seldom used, because income taxes and sales taxes have become the main sources of government revenue. Protective tariffs are used more often. However, protective tariffs have also been reduced substantially in many countries since World War II ended in 1945.

Tariffs may also be classified according to the way in which they are levied. *Specific tariffs* are calculated according to a product's weight or volume. For example, a government may levy a specific tariff on a product at a rate of 10 cents per kilogram or 25 cents per litre. Most specific tariffs are levied against such raw materials as iron ore and rubber and such food products as sugar, wheat, and wine. *Ad valorem tariffs* are levied as a percentage of the value of a product. For example, a rate of 5 per cent may apply to imports of such manufactured products as cars.

Why tariffs are levied

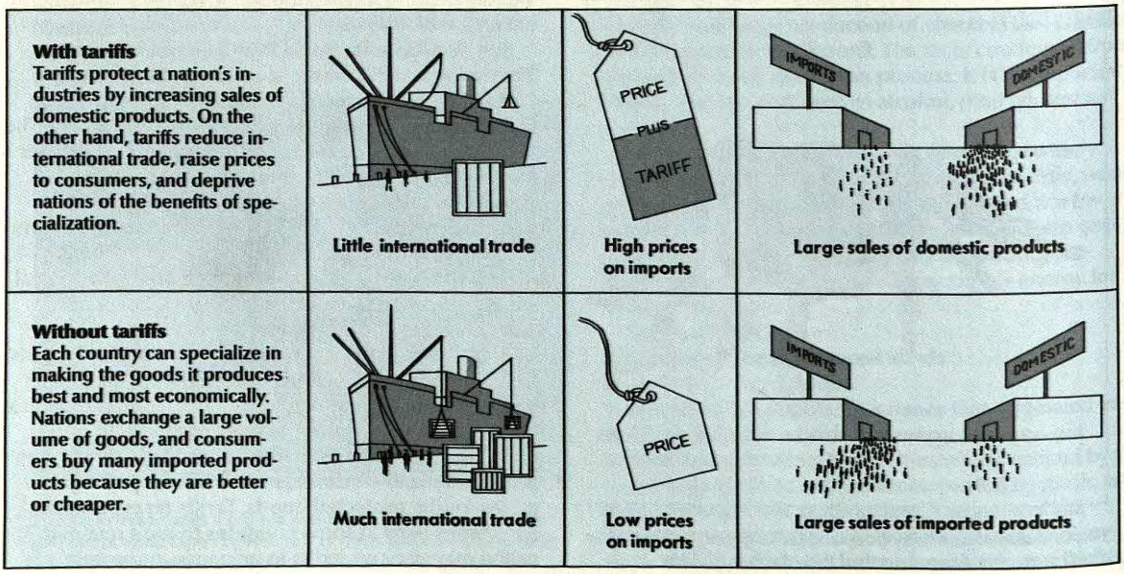
Tariffs are often levied (1) to protect domestic jobs, (2) to protect new industries, (3) to offset unfair trade practices of other countries, or (4) to prevent dependence on foreign products.

Protecting domestic jobs. Firms and workers sometimes have difficulty competing with imports when foreign firms and workers are more efficient. The affected groups may promote tariffs to increase or maintain company profits and keep wages high.

Protecting new industries. In some instances, a new industry cannot compete successfully with established industries in other countries. A protective tariff may shield the new industry from foreign competition until its workers and firms become more productive.

Offsetting unfair trade practices. Some governments use tariffs to protect their industries from the effects of *export subsidies* and *dumping.* Export subsidies are support payments paid by a government to its export industries. Such payments are designed to allow the industries to compete in a foreign market by selling their goods for less overseas. Dumping involves pricing items below their production cost to drive competitors out of an import market. For example, radio manufacturers in one country may sell their products so cheaply in another country that radio firms in the importing nation cannot compete successfully. As a result, those firms may go out of business. The importing nation would then have to depend on foreign manufacturers for radios. The foreign firms could then raise prices far above their original levels.

What Protective tariffs do Nations levy protective tariffs to guard their industries from foreign competition. The tariffs make imported products more expensive and thus encourage people to buy goods produced in their own country. But most economists believe tariffs reduce world prosperity by discouraging trade.



With tariffs
Tariffs protect a nation's industries by increasing sales of domestic products. On the other hand, tariffs reduce international trade, raise prices to consumers, and deprive nations of the benefits of specialization.

Without tariffs
Each country can specialize in making the goods it produces best and most economically. Nations exchange a large volume of goods, and consumers buy many imported products because they are better or cheaper.

In some cases, export subsidies or dumping may not harm an importing country's industries. In such cases, if no tariff is imposed, consumers may benefit from the lower prices that result from these practices.

Preventing dependence on foreign products. Many nations do not want to depend on other countries for such essential products as petroleum, steel, or food. Supplies of these products from foreign sources may be cut off or disrupted in time of war or international tension. Thus, some nations use tariffs to protect industries that produce these goods.

Arguments against tariffs

Arguments against tariffs include the belief that they result in (1) higher prices, (2) industrial inefficiency, and (3) unfair support for some industries. Tariffs may reduce trade, and so lower the standard of living.

Higher prices. Many people believe tariffs waste a nation's supply of labour and natural resources and thus raise prices. A country wastes money if it tries to produce everything it needs. Therefore, it should produce chiefly what it makes best and most economically. If a country has excellent factories but poor farmland, for example, it should export manufactured products and import most of its food. If such a nation tries to expand its farming by placing a tariff on imported food, its people will have to pay higher prices for food. In addition, many people who believe that certain industries must be protected think that it is better to support them with direct subsidies than with tariffs. Unlike tariffs, subsidies do not raise consumer prices.

Industrial inefficiency. Tariffs may encourage inefficiency by protecting industries from competition. Without competition, an industry has little need to become more efficient. If a nation's tariff policy encourages inefficiency, its industries will lose business to those of more efficient countries.

Unfair support for some industries. Tariffs may help some industries—but only at the expense of others. If a high tariff protects a nation's aluminium industry, for example, aluminium might cost more in that country than it would without a tariff. All domestic industries that use aluminium would save money if they could buy the imported product at a lower price. But the tariff forces those industries to pay the higher price.

History

Tariff policies reflect the economic and political conditions within various countries. Throughout history, nations have changed their tariff policies to keep in step with their economic and political goals.

The first tariffs. In early times, nations did not have well organized foreign trade nor formal tariffs—but they did collect such taxes. Collectors simply charged merchants the highest duties they thought they could get.

From about 1100 to 1300, the Christian military campaigns called the Crusades brought increased trade between Europe and the Middle East. The rise in trade led to formal tariffs during this period. The first tariff agreements were made by Italian trading cities, such as Genoa and Venice, with various commercial partners in Africa and Asia. England levied a revenue tariff in 1303 that included an ad valorem duty on imported and exported goods. Collectors based this duty, called *poundage,* on the value in pounds of the goods.

Beginning in the 1490's, the explorations of Christopher Columbus, Vasco da Gama, and other Europeans resulted in a great increase in foreign trade. European trading nations began to follow an economic policy called *mercantilism* which flourished until the 1700's. This policy involved the use of high tariffs to limit imports, so that exports would exceed imports. An excess of exports over imports produced a *favourable balance of trade*—and boosted the size of a nation's treasury.

The changing role of tariffs. During the late 1700's, the beginning of industrialization in Europe led to a major change in the role of tariffs. The production of goods increased in the industrial nations, such as Belgium and Great Britain. These nations wanted to sell more products to other countries. Many industrial nations, in an effort to increase trade, sought lower tariffs with their trade partners. But nations that were just beginning to industrialize kept tariffs high to protect their new industries. Efforts to reduce tariffs increased as industrialization progressed during the 1800's and 1900's.

Modern tariff policies. By the 1950's, three major trading groups had developed. These groups were (1) the chief Western industrialized countries, (2) the less developed countries, and (3) the Communist countries. The major Western industrialized countries sought to increase their trade by reducing existing tariffs through international negotiations. These negotiations took place under a treaty called the General Agreement on Tariffs and Trade (GATT). Since the late 1950's, Western European countries, as members of the European Union or the European Free Trade Association, have eliminated almost all tariffs on each other's goods. Many developing countries in Africa, Asia, and Latin America continue to use high tariffs to protect their industries. Traditionally, imports and exports of Communist countries were controlled by centralized economic planning, and tariffs did not play an important role. After 1980, however, a number of Communist governments relaxed strict control of their economies. They expanded their countries' international trading and became concerned with winning favourable tariff treatment from Western industrialized nations. In the late 1980's and early 1990's, the Communist trading group largely disintegrated after non-Communist governments replaced the Communist governments of many Eastern European countries and of the Soviet Union which was dissolved in 1991. The new governments continued to seek favourable tariff treatment, especially from Western nations.

Related articles in ***World Book*** include:

Balance of payments
Customs union
European Union
European Free Trade Association
Exports and imports
Free trade
General Agreement on Tariffs and Trade
International trade
Mercantilism

Tarkington, Booth (1869-1946), was an American novelist and dramatist. His writings are considered one of the best mirrors of the wholesome aspects of life in the Midwestern United States. Tarkington's works range from the sentimentally romantic *Monsieur Beaucaire* (1900) to the humour of *Penrod* (1914) and the realism of *Alice Adams* (1921). His trilogy of novels called *Growth* (1927) presents a cross-section of city life such as it was

Booth Tarkington

in his home town, Indianapolis, Indiana, U.S.A. The trilogy consists of *The Turmoil* (1915), *The Magnificent Ambersons* (1918), and *The Midlander* (1923). *Penrod, Penrod and Sam* (1916), and *Seventeen* (1916) portray the joys and problems of young people.

Tarkington also published plays, short stories, and essays. He was amiable, optimistic, and somewhat passive in emphasizing the smiling aspects of life and the joys of boyhood. Tarkington was awarded two Pulitzer Prizes for literature, in 1919 and 1922, for *The Magnificent Ambersons* and *Alice Adams.*

Tarkington was born on July 29, 1869, in Indianapolis. He was elected to the Indiana House of Representatives for the 1902-1903 term. He was a neighbour and admirer of the poet James Whitcomb Riley, and a devotee of William Dean Howells and Mark Twain. Tarkington also wrote some of the verses that were sung in the *Ziegfeld Follies* in the early 1900's.

Several of Tarkington's short stories dealing with political life were collected into one work entitled *In the Arena.* He also wrote *The Gentleman from Indiana* (1899), *The Beautiful Lady* (1905), *Beauty and the Jacobin, an Interlude of the French Revolution* (1912), and *The Plutocrat* (1927).

Tarnish. When a metal rusts, or combines with oxygen, it is tarnished. When a metallic or mineral surface loses its lustre, it is also tarnished. The word *tarnish* is used for rust formed on metals other than iron, or *nonferrous* metals.

See also **Rust.**

Taro is a tropical plant used as food. The edible portion of the plant consists of one or more large, starchy underground stems. The taro is grown in many wet tropical regions, including Hawaii, the Caribbean, and West Africa. Several different forms of the plant are cultivated. Known as taro in the Pacific, the plant is called *eddo* or *dasheen* in the Caribbean and *cocoyam* in West Africa. The taro is closely related to the ornamental plants called *elephant's-ear* and *caladium.*

Scientific classification. The taro belongs to the arum family, Araceae. It is *Colocasia esculenta.*

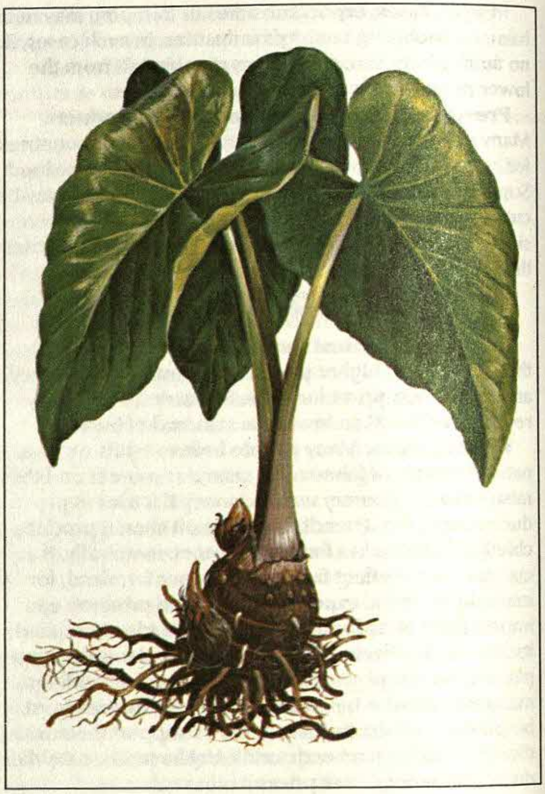
See also **Elephant's-ear.**

Tarot cards. See **Magic** (History; picture).

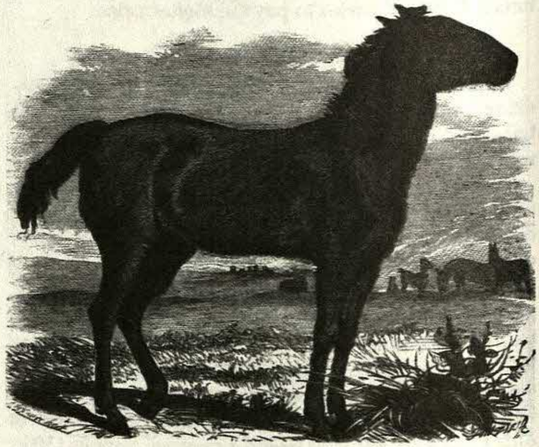
Tarpan was a wild horse that lived in the forests of Europe and on the *steppes* (vast plains) of Russia. It has been extinct since the 1800's. Scientists believe that they have bred a horse that is exactly like the original European forest horse. These scientists worked at the Hellabrunn Zoo in Munich, Germany. They developed a process of back-breeding which produced a small horse in the 1950's that looks like the ancient tarpan.

See also **Horse** (Wild horses); **Przewalski's horse.**

Tarpon is a large game fish that resembles a herring. It lives in the Atlantic Ocean from Long Island, New York, U.S.A., to Brazil, in the Gulf of Mexico, and in West Indian waters. It is abundant off the southern Atlantic Coast of the United States. It also is found off the coasts of Spain, Portugal, and the Azores. The tarpon grows to a length of 2.5 metres and may weigh as much as 90 kilograms. Its flesh is coarse and not desirable for food. Most fishing for tarpon is done off the south Atlantic Coast. Tarpon enter fresh waters and may be seen rolling, giving off bubbles of air as they dive. Sometimes they leap out of the water.



The taro plant has a large, starchy underground stem. The stem is sometimes used as food.



The tarpan was a wild horse that roamed the grasslands and forests of Europe and Russia.

Scientific classification. Tarpons belong to the tarpon family, Elopidae.

See also **Fish** (picture: Fish of coastal waters).

Tarquinius was the name of two of the seven legendary kings of Rome.

Lucius Tarquinius Priscus (reigned 616-578 B.C.) was the fifth king. According to legend, he was born in Etruria and was not of royal blood. He moved to Rome and became a good friend of the king, Ancus Marcius, who made him guardian for his children. When the king died, Priscus was elected to his place. His reign was very prosperous and successful. He made many conquests, and built many monuments and public works, including the Circus Maximus and the Temple of Jupiter. Legends claim that either Priscus or his son Superbus acquired the Sibylline books of prophecy. See **Sibyl**.

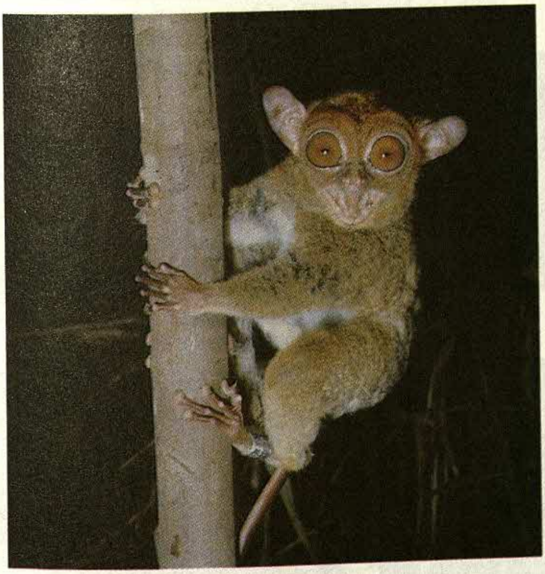
Lucius Tarquinius Superbus, the Proud (reigned 534-510 B.C.), was the son of Priscus, and the last of the seven legendary kings. He was the son-in-law of Servius Tullius, whom he murdered in order to gain the throne. Superbus was a tyrant and took away the rights of the lower classes. When his son, Sextus Tarquinius, committed a crime against Lucretia, the people revolted and drove Superbus from the throne. Then the people established the Roman Republic. They also put down several attempts to bring Superbus back. The most famous attempt, by Lars Porsena, inspired Thomas Macaulay's poem "Horatius at the Bridge."

Tarragon is a plant that provides leaves used to flavour meats, vegetables, sauces, dressings, vinegar, and cooking oil. It originated in southern Europe. Tarragon is a bushy plant, with smooth narrow leaves. It grows to a height of about 150 centimetres, in warm, dry places.

Scientific classification. Tarragon belongs to the family Compositae (Asteraceae). It is *Artemisia dracunculus.*

Tarsal bones. See **Foot** (in anatomy).

Tarsier is a small mammal with a round head and unusually large owllike eyes. Like humans and apes, it belongs to the order *Primates* (see **Primate**). The tarsier lives in Indonesia and the Philippines. It has big ears and a long, thin, hairless tail. It has short front legs, and long hind legs that help it hop among the branches of its tree-home. All of its long fingers and most of its toes have nails, but the second and third toes have claws. Tarsiers cannot move their eyes. But they can rotate their heads almost completely to see around them. The tarsier grows to be about as large as a rat. Its tail measures up to 25 centimetres long. Its name comes from the long tarsal bones in the animal's feet. The tarsier sleeps during the day and moves through trees at night, feeding on insects, snails, and small lizards.



The tarsier is a small Southwest Pacific animal with large eyes. Pads on its fingers and toes help it grip branches.

Scientific classification. The tarsier belongs to the tarsier family, Tarsiidae. It is genus *Tarsius.*

Tarsus (pop. 146,502), a city in south-central Turkey, is an agricultural centre. Tarsus was the birthplace of Saint Paul. Ancient Tarsus was an important trading centre, surrounded by fertile land. The Cydnus (now called the Tarsus) River linked the city with a good harbour on the Mediterranean Sea, and an important trade road ran through Tarsus. For location, see **Turkey** (political map).

Tarsus was first mentioned in the records of the Assyrians, a group of people from western Asia. The Assyrians probably seized control of the city in about 850 B.C. from Greek colonists. After 67 B.C., the Romans took control of Tarsus. The city was ruled by the Roman Empire, and later by the Byzantine Empire, for several hundred years. After the A.D. 600's, many different groups ruled Tarsus. In the 1500's, the Turks made Tarsus part of the Ottoman Empire.

Tartan is a plaid cloth pattern that developed chiefly in Scotland. The design consists of stripes of various widths and colours. The stripes cross at right angles against a solid colour background. The principal *clans* (tribes) in Scotland have their own tartans. Scottish regiments have also adopted tartans. In countries other than Scotland, the word *tartan* also means a cloth or a garment with a tartan design.

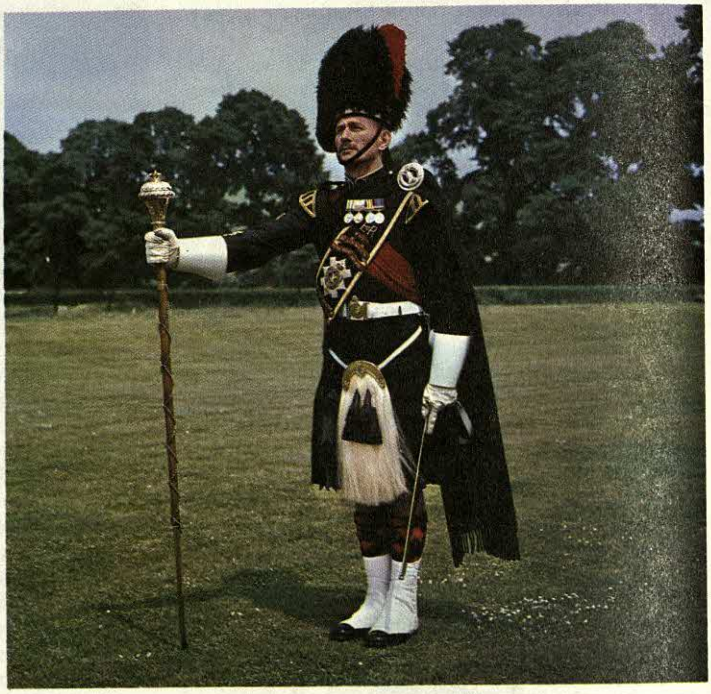
The cloth that is used to make tartan is usually wool. A tartan design is called a *sett.* The sett may be made in any size, depending on the intended use of the cloth. Regardless of the size of the sett, the proportions of the stripes must remain the same. The colours of a sett may vary in shade from pale to dark.

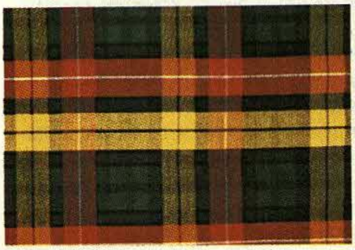
A Scottish Highlander wears a tartan *kilt* (a knee-length pleated skirt) and may carry a *plaid* over the left shoulder. A plaid is a blanketlike mantle fastened at the shoulder with a brooch. Other parts of the costume include a *sporran* (pouch) hanging in front of the kilt, a *doublet* (jacket), and a *bonnet* (cap). The stockings may be of tartan pattern, and the *brogues* (shoes) are low-cut. Tartan *trews* (trousers) are sometimes worn as an alternative to the kilt by the Lowland Scottish regiments.

The use of chequered garments dates back to ancient times. The Irish, the Britons, the Caledonians of Scotland, and the Celts in Europe wore them. Originally, tartans in Scotland were associated with districts. Later, they were used to identify the chief clan of an area. Extra lines were added to some setts to show the wearer's rank.

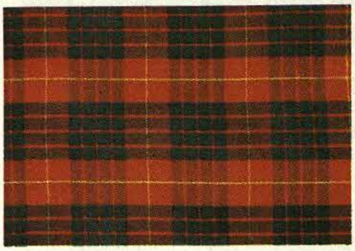
Originally, the kilt and the plaid were part of a single large piece of tartan cloth. Wearers folded the tartan lengthwise and gathered it around the waist with a belt.

Colourful Scottish tartans are favourite designs in many countries. The tartan developed chiefly in the Highlands of Scotland, where each clan and family designed its own pattern. Some Scottish clans wear a bright tartan on formal occasions, and a more restrained hunting tartan for everyday wear. There are hundreds of different tartans. Some of the best-known clan tartans are illustrated in this article. Because of the problem of matching dyes, the colours of different samples of the same tartan may differ in shade. The uniform of the famous Black Watch Royal Highland Regiment, *right,* includes the government tartan. The soldier is a drum major in the regiment, which was organized in 1725.

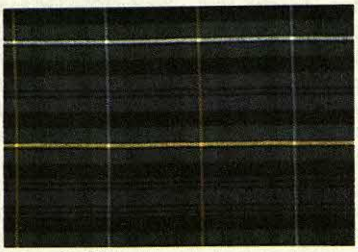




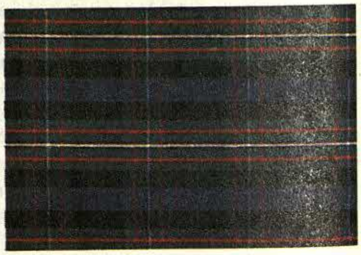
Buchanan



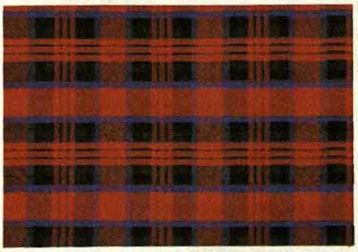
Cameron



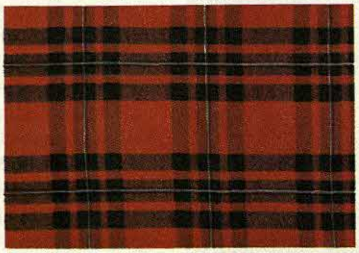
Campbell



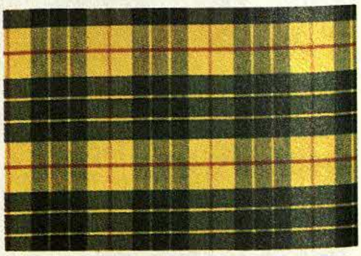
Ferguson



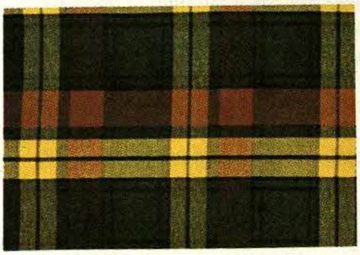
MacDuff



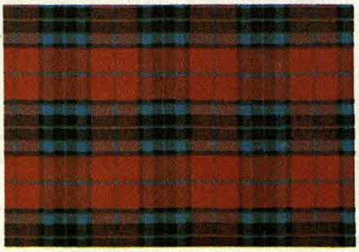
MacGregor



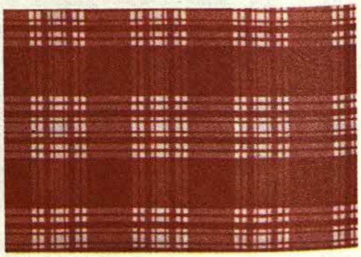
MacLeod of Lewis



MacMillan, Ancient



MacTavish



Menzies, Dress

They threw the rest over the shoulder and pinned it. In bad weather, they wore it over the head and shoulders. When sleeping outside, they used it as a blanket. Today, a smaller kilt called a *filibeg* and the plaid are worn separately.

After the Jacobite Rebellion in 1745, the British Parliament banned tartan and the use of Highland dress until 1782. Some old setts were lost, but many new ones were invented, especially about 1820, when the works of Scottish writer Sir Walter Scott awakened interest in Highlands traditions. Today, the tartan is popular throughout the world, particularly in the United States, where many people have Scottish ancestors. There are no rigid rules for its use, but people usually wear tartans associated with their name or ancestry.

See also **Clan**; **Scotland** (Way of life; Traditions; picture: Bagpipes and kilts).

Tartar emetic is a medicinal preparation once used to cause vomiting. It is now used to make patients cough up phlegm and mucus. Tartar emetic is prepared from antimony oxide and potassium tartrate. In large doses, it is a violent, irritating poison. Tartar emetic should be taken only when prescribed by a doctor.

Tartaric acid is an organic chemical that occurs naturally in grapes and several other fruit. It is commonly used in the production of jams and carbonated grape beverages. Most commercial tartaric acid is obtained as a byproduct of the wine industry. The acid's colourless crystals are derived from potassium hydrogen tartrate, or *argol,* which collects on the walls of wine vats during the fermentation of grapes.

Three salts of tartaric acid—cream of tartar, tartar emetic, and Rochelle salt—are used by the food industry and other industries. Cream of tartar is an ingredient of some baking powders and is also used in making hard sweets. Tartar emetic and Rochelle salt are used in some medicines. Crystals of Rochelle salt, which are *piezoelectric,* are also an important part of some microphones (see **Piezoelectricity**). In addition, tartaric acid and some of its salts are used in cleaning and polishing metals and in dyeing fabrics.

Tartaric acid was first isolated by Carl W. Scheele, a Swedish chemist, in 1770. The acid has the chemical formula $C_4H_6O_6$.

See also **Acid**; **Cream of tartar**; **Tartar emetic**.

Tartars. See **Tatars**.

Tartarus was a deep pit below the surface of the earth in early Greek mythology. It was as far below the surface as heaven was above the earth. High walls and a river of fire called Phlegethon (or Pyriphlegethon) encircled Tartarus. Zeus, ruler of the gods, imprisoned the rebellious gods called Titans there. Any god who swore a false oath by the Styx River in the Underworld was kept in Tartarus for nine years (see **Styx**). In later Greek and Roman belief, Tartarus was a place of punishment for the most wicked sinners, and was part of Hades, the kingdom of the dead (see **Hades**). In some ways, Tartarus resembled the Christian idea of hell.

Tartary was once the name of a vast region in Europe and Asia which was inhabited by tribes of Tatars. The region lay outside the Great Wall of China. It included present-day northern China, Mongolia, Xinjiang, and the southern parts of Russia. Today, the name Tartary usually applies only to the area commonly known as Xinjiang, or Chinese Turkestan, as well as most of western Mongolia.

Tartini, Giuseppe (1692-1770), was an Italian violinist, composer, and teacher. He influenced violin playing by introducing a system of violin bowing and fingering. He started the use of thicker strings and lighter bows. In 1728, he founded a school of violin playing at Padua.

Tartini's best-known composition for violin is the *Devil's Trill Sonata.* He also composed about 140 concertos, 40 trios, 150 violin sonatas, and wrote essays on violin playing methods and the theory of acoustics. Tartini was born in Pirano, Istria, now in Croatia.

Tartu (pop. 110,000) is the second largest city in Estonia. Only Tallinn has more people. Tartu lies along the Emajõgi River in eastern Estonia (see **Estonia** [map]).

Tartu is a major educational and cultural centre. It is the home of Tartu State University, founded in 1632. Tartu is also the home of the Estonian Academy of Agriculture and other schools of higher education, and the Vanemuine, an old drama and musical theatre. Tartu's industries include food processing and the production of leather and wood products, machine tools, and textiles.

The earliest settlement at Tartu was begun in the A.D. 400's. Tartu was founded as a city in 1030. It was part of the independent nation of Estonia from 1918 to 1940. In 1940, Russia seized Estonia and forced it to become part of the Soviet Union. In 1991, the Soviet Union collapsed and Estonia became an independent nation again.

Tarzan. See **Burroughs, Edgar Rice**.

Tasadays. See **Philippines** (People).

Tashkent (pop. 1,986,000) is the capital of Uzbekistan, a country in Asia. In 1991, shortly before the Soviet Union was dissolved, the Uzbek republic declared itself independent.

Tashkent lies north of Afghanistan, in the valley of the Chirchik River (see **Uzbekistan** [map]). The city is divided into two sections. The new section reflects modern city life. The old section resembles a dusty caravan town. Tashkent has machinery plants and a cotton-textile mill. It is the regional centre for the production of cotton fabric.

Tasman, Abel Janszoon (1603-1659), a Dutch sea captain, explored the South Pacific Ocean. In 1642, he sailed from Java and became the first European to visit Van Diemen's Land (now Tasmania) and New Zealand. His course took him right around the mainland of Australia, but he was not aware of this. He did not sight the mainland. In 1644, on his second voyage, he explored the northern and western coasts of Australia.

Early life. Historians know little about Tasman's early life and his personality. There is disagreement on the exact places and dates of his birth and death. Tasman was probably born at the Hoorn, in the Netherlands. In 1633, he went to Java, where he became captain of a small ship that carried spices from the Moluccas to Batavia.

The first voyage. The Governor of the Dutch East Indies, Anthony van Diemen, wished to extend Dutch power in the South Pacific Ocean. In 1642, Tasman was appointed commander for an important voyage of exploration. Francis Visscher, another skilled Dutch sailor, was chief navigator and second in command. Visscher drew up the plans for the voyage with three objectives.

The first was to explore the known *South Land* (New Holland, or Australia). The second was to see if there was another "South Land" that was as yet unknown. The third was to find a good trade route to Chile.

On Aug. 14, 1642, two ships sailed from Batavia. One ship was the *Heemskerck,* a war yacht of 61 metric tons, carrying a crew of 60 men. The other ship was the *Zeehaen,* a long, narrow vessel of 102 metric tons, with 50 men. On September 6 they reached the island of Mauritius. On October 8, they left Mauritius. They sailed southward until they reached latitude 49° south. They did not sight land. They struck extremely bad weather, including hail and snow that made sailing difficult. Tasman sought Visscher's advice. Visscher decided not to follow the plan of instructions. He advised Tasman to turn and sail north, and then sail east to the longitude of the Solomon Islands.

In latitude 42° south, westerly winds drove them toward land. On Nov. 24, 1642, Tasman came to the western coast of an island (Tasmania) that he named *Van Diemen's Land.* Visscher took some men ashore. They reported seeing notches cut 1.5 metres apart in trees as some kind of steps. They heard strange music and saw fires, but could see no people. They thought that the land must be a land of giants. For 12 days they remained on the coast but did not explore it. Tasman had a flag raised on the southeastern shore of what is now called *Cape Frederick Henry,* taking possession of the land for the Netherlands.

On December 4, Tasman and Visscher sailed east, looking for the unknown South Land. Heavy sea swells from the southwest made them sure that there could be no mainland to the south. For this reason, they continued eastward. The crew became excited on Dec. 13, 1642, when land was sighted. This land was the western coast of the South Island of New Zealand.

Tasman sailed north along the coast until he found what he thought would be a good bay to take on fresh water. But the native Maoris killed four of the crew of the *Zeehaen.* Tasman called the area where his men were killed *Murderers' Bay.* It is now known as *Golden Bay.* He called the country *Staten Land* and the stretch of water between this country and Van Diemen's Land *Abel Tasman's Passage.* It is now known as the *Tasman Sea.*

From Dec. 19, 1642, until Jan. 5, 1643, Tasman and Visscher sailed along the western coast of Staten Land. They looked for places to anchor and to obtain water and food, away from the tall, strange men whose speech they could not understand and who terrified them. Tasman believed that this land was part of the unknown South Land.

On Jan. 6, 1643, the ships sailed from the western coast. They headed northward for Java. After two weeks of sailing, they reached the islands that are now known as *Tonga.* Tasman and his crew found the islanders friendly, and exchanged gifts with them. Then they began to barter with the islanders, exchanging nails for coconuts. Tasman sailed on February 1. He still hoped to find the Solomon Islands. Four days later, just off the islands of Fiji, the ships reached coral reefs and atolls that made navigation difficult. Tasman decided to make his way back to Batavia by the north coast of New Guinea. He arrived in Batavia on June 15, 1643. He had failed to fulfil any of the three objectives of the voyage. He had gained a great deal of geographical knowledge, but the council was not impressed. It wanted only profits and treasures for the company.

The second voyage. Governor Van Diemen and his council felt that Tasman had lacked enterprise in not finding the answers to their questions. They arranged a second voyage. This time, they asked Tasman to find out if there was a passage between New Guinea and the South Land, if Van Diemen's Land was joined to New Guinea, and which islands were between the unknown South Land and New Guinea. Tasman was also asked to search for a suitable place for Dutch ships to call for food and water on their way from the Netherlands to Batavia.

With Tasman in command, two ships—the *Limmen* with a crew of 56 and the *Zeemeeuw* with 41—and a fishing boat, the *Bracq,* with only 14 crew members, left Batavia on Jan. 29, 1644. The ships sailed to the Indonesian islands of Ambon and Banda, to Cape Valsch in New Guinea, and from Cape York Peninsula down the Gulf of Carpentaria. Tasman decided that there was no passage between New Guinea and this South Land. He then sailed along the northern and western coasts of the South Land. For some unknown reason, when Tasman reached Willem's River (now the Gascoyne River), he headed for Batavia. The voyage lasted only six and a half months, although provisions were available for at least eight months. Tasman reached Batavia on Aug. 10, 1644.

The council was again disappointed with Tasman's voyage. His description of this South Land was not an attractive one. He reported that the people (Aborigines) seemed extremely poor and did not wear clothes. They had no rice and no fruit of any significance. They appeared hostile.

Tasman's two ships for his voyage around Australia in 1642, the *Heemskerck* and the *Zeehaen,* were both quite small. They averaged a speed of only about 5 knots and covered the 1,600 kilometres between Tasmania and New Zealand in about 8 days.

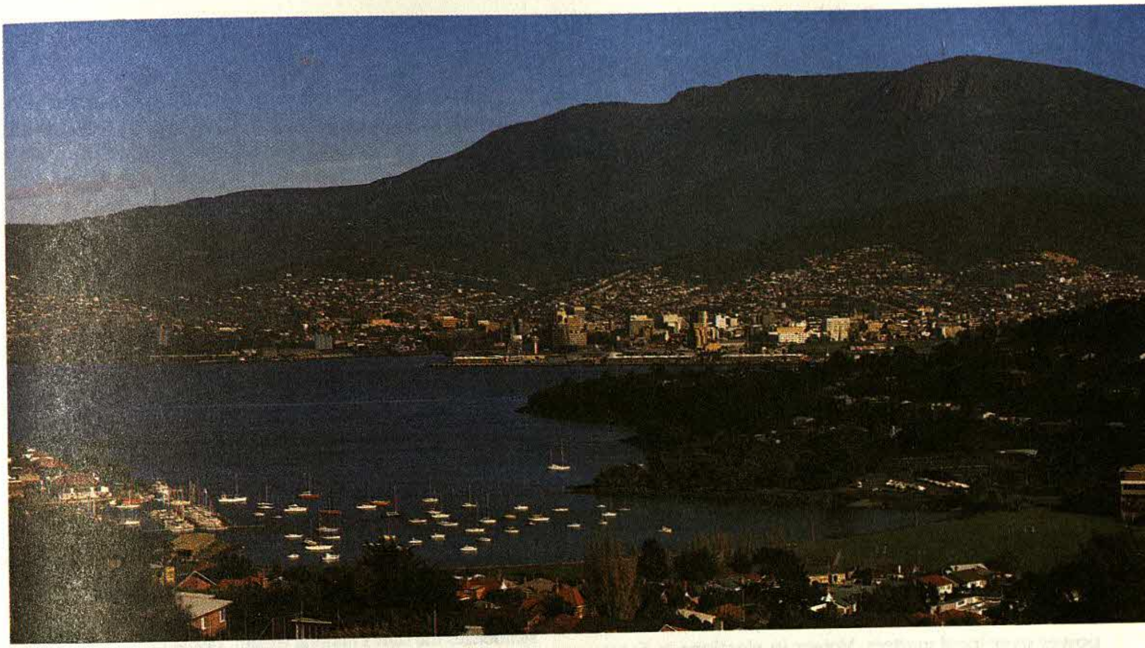
Later life. In 1649, Tasman committed a serious crime. While in the Philippines as commander of a Dutch expedition, he spent the day with other officers, feasting at a monastery. On returning to his ship, he accused two sailors of disobeying his command. Tasman ordered other sailors to put a halter around the neck of one of them and to hang him from a nearby tree. Tasman realized the agony of the poor sailor and allowed him to drop to the ground. The sailor appeared dead, but survived. Because of this incident, Tasman was suspended from the company for two years. But, in recognition of his services, he was reinstated. Tasman became a rich man, owning a large amount of land in Batavia.

See also **Tasmania.**

Tasman Bridge crosses the Derwent River, in Tasmania, connecting Hobart's eastern shore with the city centre. The prestressed concrete bridge was opened in 1964. See also **Hobart.**

Tasman Peninsula is located in southeastern Tasmania. It is joined to the Forestier Peninsula by a narrow strip of land at Eaglehawk Neck. The peninsula is named after the Dutch navigator Abel Tasman.

Tasman Sea is that part of the Pacific Ocean which lies between southeastern Australia, Tasmania, and New Zealand. It covers about 2,300,000 square kilometres.



Hobart, the capital city of Tasmania, is located on the beautiful Derwent River. The state advertises itself as *The Holiday Isle* because its scenery attracts visitors from other parts of Australia.

Tasmania

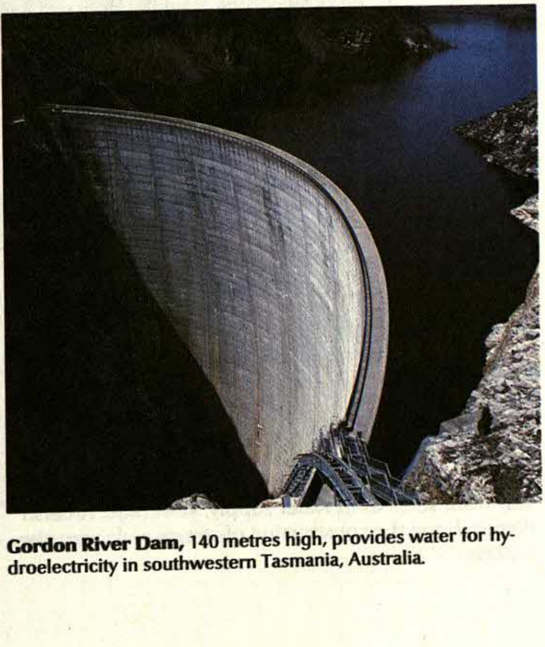
Tasmania is the smallest state in Australia. It lies off the southeastern corner of the Australian continent. It is separated from the mainland by Bass Strait, which is only 240 kilometres wide. This shallow sea varies in depth from 55 to 90 metres. Before the thawing of the world's ice cap about 8,000 to 12,000 years ago, this stretch of water was dry land.

Tasmania advertises itself as *The Holiday Isle.* Its great variety of scenery and its historic relics attract many tourists. It is often called *The Apple Isle,* even though apples ceased to be an important crop after Tasmania lost its British markets in the 1970's.

Two marsupials are native only to Tasmania—the *Tasmanian thylacine* and the *Tasmanian devil.* The Tasmanian thylacine is commonly known as the *Tasmanian tiger* because of the stripes on the lower part of its back. It is also known as the *Tasmanian wolf.* No positive sightings of this animal have been made since the 1930's, and it is believed to be extinct. Tasmanian devils, on the other hand, are plentiful. These animals get their name from the shrill scream they often make at night.

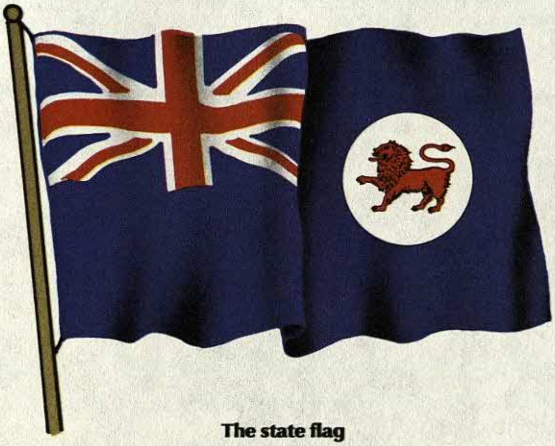
Facts in brief about Tasmania

State capital: Hobart.
Largest towns: Hobart, Launceston, Glenorchy, Devonport.
Area: 67,800 km². Smallest state.
Population: *1991 census* 452,847.
Floral emblem: Southern Blue Gum.
Chief products: *Agriculture*—beef, dairy products, fruit, hops, lamb and mutton, potatoes, wool. *Fishing*—abalone, mussels, oysters, rock lobster, salmon, shark, scallops, trout. *Forestry*—newsprint, timber, woodchips. *Manufacturing and processing*—beer and cordials, coal, cement and cement products, clothing, dairy products, frozen and canned vegetables, glass, newsprint, paper pulp, paper, plastics, printing inks, sulphuric acid, timber, titanium products, zinc. *Mining*—coal, copper, iron, lead, scheelite, sulphur, zinc.

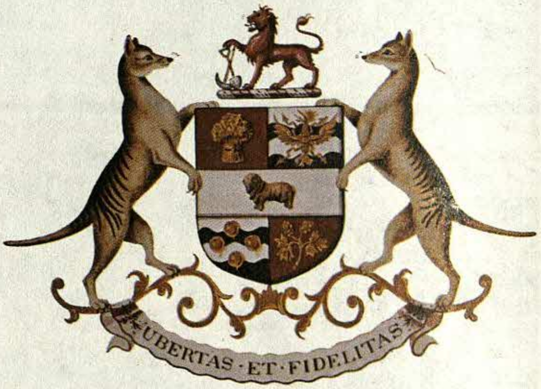


Gordon River Dam, 140 metres high, provides water for hydroelectricity in southwestern Tasmania, Australia.

Government



The state flag



State coat of arms

Symbols of Tasmania. The state flag, which bears a British lion, was adopted in 1975. The state coat of arms was proclaimed in 1917. The shield shows a sheep, apples, hops, and wheat, all of which represent the island's agriculture and a heraldic thunderbolt, which represents the island's hydroelectricity. Above the shield, a British lion holding a pick axe and a spade symbolizes the state's mineral wealth. Tasmanian tigers support the shield. The Latin motto beneath the shield means *Productivity and Fidelity*. The state's floral emblem is the Tasmanian blue gum. The unofficial faunal emblem is the marsupial Tasmanian devil. The unofficial state bird is the green rosella parrot.

Government in Tasmania is at three levels. The Australian federal government in Canberra deals with matters that concern the whole country. The state government in Hobart deals with affairs confined to Tasmania.

The 6 cities and 40 municipalities in Tasmania have power over local matters. Voters in elections in Tasmania must be at least 18 years of age. They must have lived in the state for at least six months.

Tasmania has two houses of parliament. The House of Assembly is the lower house. It has 35 members whose terms last for a period of four years.

Under the leadership of the premier and the premier's cabinet, the House of Assembly governs the state. The members of the House of Assembly are elected by the Hare-Clarke system of proportional representation (see **Proportional representation**). Tasmania is the only state to use this system. Its main feature is that it elects candidates who win a certain quota of ballots. It then distributes their surplus votes to candidates still awaiting election.

The Legislative Council is the upper house, or house of review. It considers legislation from the House of Assembly. It may amend bills before approving them. The Legislative Council has 19 members who are elected to six year terms. Voting for the Legislative Council is compulsory.

The units of local government are the 6 cities and 40 municipalities. Each municipality is divided into wards. Ratepayers living in the wards elect councillors to serve for a period of three years. A third of the councillors are chosen each year at elections in April. Following each election, the councillors choose a warden from among their own number.

Burnie, Clarence, Devonport, Glenorchy, Hobart, and Launceston have city status. City ratepayers elect aldermen each year. Voting in local government elections is not compulsory. In Hobart, the ratepayers elect their own lord mayor. In the cities of Devonport, Glenorchy, and Launceston, they elect a mayor.

All municipalities and city councils in Tasmania have the power to levy rates in order to raise money to provide such services as water supply, sewerage, rubbish disposal, and the construction of streets and recreation facilities.

Floral emblem
(Tasmanian blue gum)

Parliament House stands in attractive gardens in Hobart. The original building was erected between 1835 and 1842.

People

The population of Tasmania in the 1991 census was 452,847. Most people live in urban areas such as Hobart, Launceston, and Devonport. Other large municipalities with considerable populations are Burnie, Clarence, George Town, Kingborough, New Norfolk, Circular Head, Ulverstone, Westbury, Scottsdale, Longford, Penguin, Latrobe, Queenstown, Zeehan, Deloraine, and Beaconsfield. The towns along the northwest coast act as service centres for a fertile farming strip inland. Climate and physical features help determine the number of people living in a particular spot. For example, many people avoid the west coast because of its cold, wet winters and mountainous countryside. The area is also isolated from other main population centres. Most of Tasmania's people were either born in the state, or came from Britain or other Commonwealth countries. Since World War II (1939-1945), many settlers have come from the European mainland. The number coming from nonEuropean countries is growing steadily.

Education

Tasmania has played a leading role in the development of education in Australia. In 1869, Tasmania became the first colony in the British Empire to make education compulsory. In 1898, school attendance was made obligatory between the ages of 7 and 13 and, in 1912, between the ages of 6 and 14. In 1946, Tasmania became the first state in Australia to raise the school-leaving age to 16 years.

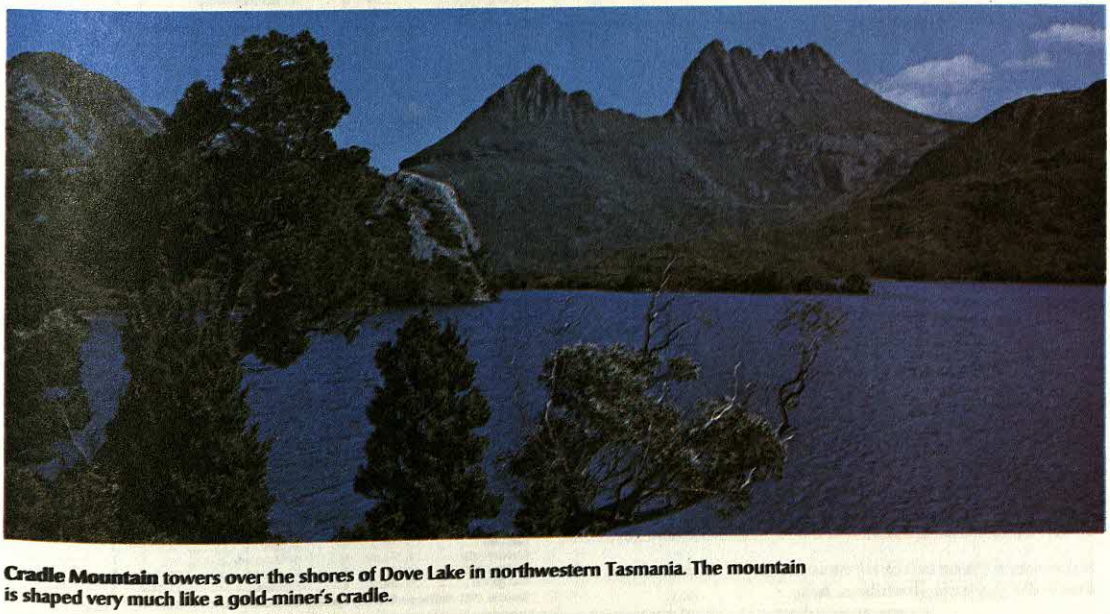
All government schools, except two, are coeducational. Most children attend state schools, but about one out of every four is enrolled at a private school. Roman Catholic schools have the greatest number of pupils. Protestant denominational schools include the Hutchins School, founded in 1846, and the Friends School, founded by the Society of Friends in 1887. Children under 6 can attend preschools or kindergartens.

Pupils move from primary to secondary schools without having to take an entrance examination. After four years, students wishing to continue their education in government schools can go on to one of the seven secondary colleges. A Tasmanian Certificate of Education was introduced in 1988. It records all successful awards in subjects taken by students from grade 9 in secondary school to grade 12 in secondary college. This single certificate replaces the School Certificate, given at the end of four years, and the Higher School Certificate, given at the end of a further two years.

The Division of Technical and Further Education looks after technical education, adult education, and secondary colleges. It controls technical education at Queenstown, Launceston, Burnie, and Devonport, and adult education courses in various centres. Technical education courses are available in centres where they meet a local need. The University of Tasmania, in Hobart, and the Tasmania State Institute of Technology, in Launceston, offer courses in a variety of subjects, including teacher training. Both confer degrees.

Visitor's guide

More than 680,000 tourists visit Tasmania each year. Popular beach resorts on the eastern coast include Scamander, Swansea, Coles Bay, St. Helens, and Bicheno. In the west, the wild and rugged mountains, deep river valleys, and beautiful lakes provide a different kind of natural beauty. About 20 per cent of Tasmania has been set aside as national parks under the control of the Department of National Parks. In 1982, the UNESCO World Heritage Commission declared Tasmania's three largest national parks (Cradle Mountain-Lake St. Clair, Franklin-Lower Gordon Wild Rivers, and South West) a World



Cradle Mountain towers over the shores of Dove Lake in northwestern Tasmania. The mountain is shaped very much like a gold-miner's cradle.

Heritage area. These parks form one of the three great temperate wilderness areas in the Southern Hemisphere. Within these parks lie glacial landscapes, rare plants and animals, and areas of scenic beauty.

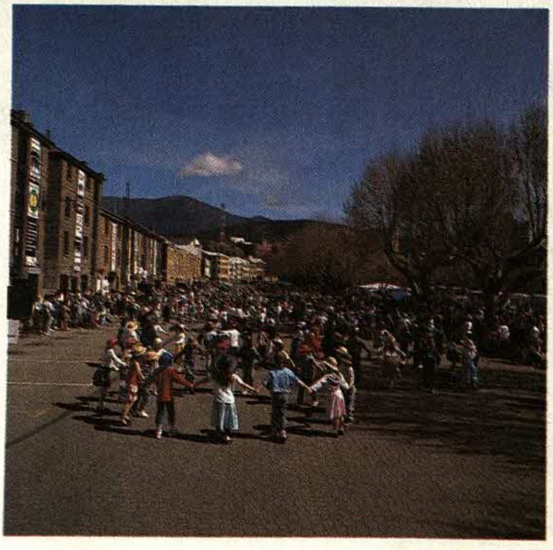
In December 1988, the Tasmanian and Australian federal governments decided to extend the area, taking in parts of the Lemonthyme and Southern Forests, and Exit Cave State Reserve. In May 1989, the area was extended even further to take in the Denison-Spires region, the Central Plateau Protected Area, the Middle Weld and Little Fisher Valleys, the Eldon Range, the southern part of Macquarie Harbour, and other adjoining lands. It now occupies about 1,350,000 hectares, or about 20 per cent of Tasmania.

Caves exist in several parts of the island. Many caves have been equipped with lighting that enables visitors to see their limestone formations. The Kutikina Cave, on the Franklin River, indicates that people lived in the region as long ago as 20,000 years. The main skiing centres are at Mount Mawson, about 100 kilometres from Hobart, and Ben Lomond, about 60 kilometres from Launceston. Fishing enthusiasts can catch rainbow trout, brown trout, and other kinds of fish. The main fishing centres include the Great Lake, Lake King William, Lake Sorrell, Lake Pedder, and the Dee-Bradys-Bronte lakes.

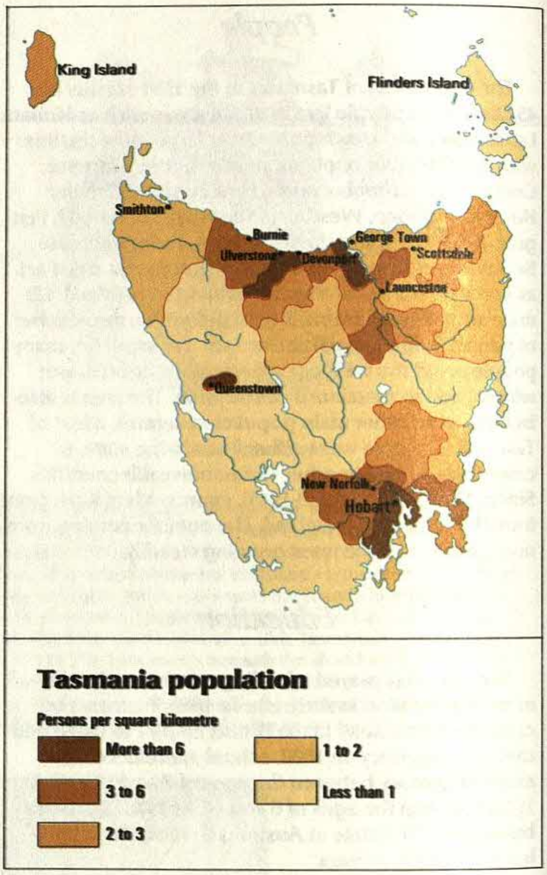
The island's many historic centres include the former penal settlement at Port Arthur, on the Tasman Peninsula.

Hobart was planned by Governor Lachlan Macquarie in 1811. Many early buildings survive. Salamanca Place and Arthur's Circus in Battery Point contain examples of early sandstone buildings. The Theatre Royal, built in 1834, is Australia's oldest theatre. Government House was completed in 1858. The town hall was opened in 1866.

Franklin House (built in 1838) and Entally House (1820) are both near Launceston. Richmond is a fine example of an early colonial village. St. Luke's Church of England church was built in 1834.



Salamanca Place in Hobart attracts many tourists. One attraction is the sandstone buildings, *left.*



Tasmania population

Persons per square kilometre

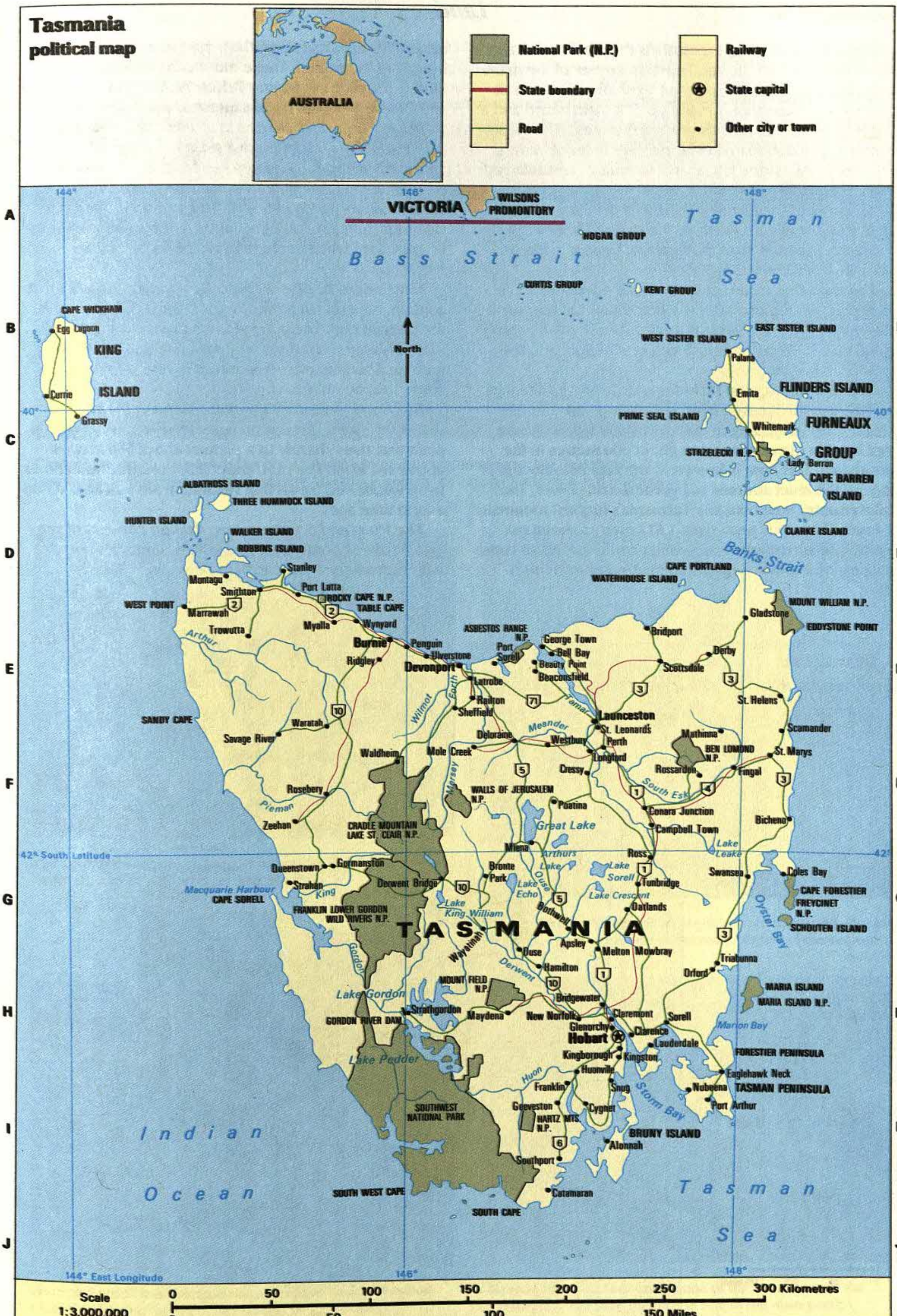
Tasmania map index

Cities and towns

Alonnah		J	6
Apsley		G	6
Beaconsfield	15,356	E	5
Beauty Point	1,064	E	5
Bell Bay		E	5
Bicheno	661	F	7
Bothwell	802	G	6
Bridgewater	8,654	H	6
Bridport	980	E	6
Bronte Park		G	5
Burnie	20,483	E	4
Campbell Town	1,357	F	6
Catamaran		J	5
Claremont		H	6
Clarence	46,282	H	6
Coles Bay		G	7
Conara Junction		F	6
Cressy	630	F	6
Currie	794	C	1
Cygnet	832	J	6
Deloraine	5,278	F	5
Derby		E	7
Derwent Bridge		G	4
Devonport	24,622	E	5
Eaglehawk Neck		J	7
Egg Lagoon		B	1
Emita		C	7
Fingal	3,156	F	7
Franklin	453	J	5
Geeveston	753	J	5
George Town	6,921	E	Y5
Gladstone		E	7
Glenorchy	42,173	H	6
Gormanston	341	G	3
Grassy	253	C	1
Hamilton	2,146	H	5
Hobart	181,838	H	6
Huonville-Ranelagh	1,305	J	6
Kingborough	23,708	H	6
Kingston	10,932	H	6
Lady Barron		C	7
Latrobe	6,763	E	5
Lauderdale	2,353	H	6
Launceston	62,506	E	6
Longford	6,404	F	6
Marrawah		D	2
Mathinna		F	7
Maydena	384	H	5
Melton Mowbray		G	6
Miena		G	5
Mole Creek	288	F	5
Montagu		D	2
Myalla		E	3
New Norfolk	10,009	H	6
Nubeena	220	J	7
Oatlands	1,935	G	6
Orford	458	H	7
Palana		B	7
Penguin	5,641	E	4
Perth	1,352	F	6
Poatina		F	5
Port Arthur		J	7
Port Latta		D	3
Port Sorell	1,173	E	5
Queenstown	3,593	G	3
Railton	906	E	5
Ridgley	427	E	4
Rosebery	2,102	F	3
Ross	448	G	6
Rossarden		F	7
St. Helens	1,149	E	7
St. Leonards		E	6
St. Marys	668	F	7
Savage River	1,058	F	3
Scamander		F	7
Scottsdale	4,694	E	6
Sheffield	934	E	5
Smithton	3,414	D	3
Snug	714	J	6
Sorell-Midway Pt	8,468	H	6
Stanley	588	D	3
Strahan	597	G	3
Strathgordon		H	4
Swansea	411	G	7
Triabunna	883	H	7
Ulverstone	13,990	E	4
Waldheim		F	4
Waratah	943	E	3
Wayatinah		G	5
Westbury	10,459	F	5
Whitemark		C	7
Wynyard	12,918	E	4
Zeehan	3,529	F	3

Source: 1991 census preliminary figures; 1986 census for smaller places.

Tasmania political map



Land

Location and size. Tasmania is the smallest state in Australia. It lies off the southeastern corner of the mainland, from which it is separated by shallow Bass Strait. The state of Tasmania is made up of a main island and a number of smaller islands around the coast. The most important of these smaller islands are Bruny, Flinders, and King. Macquarie Island is also under Tasmanian administration.

The area of the whole state is 67,800 square kilometres. It is just under one-third the size of Victoria, the smallest mainland state of Australia. Tasmania has a coastline of 3,200 kilometres.

Land regions. Tasmania can be divided into six regions. These regions are the Central Region, the Northeastern Region, the Eastern Region, the Northwestern Region, the West and Southwestern Region, and the Southern Region.

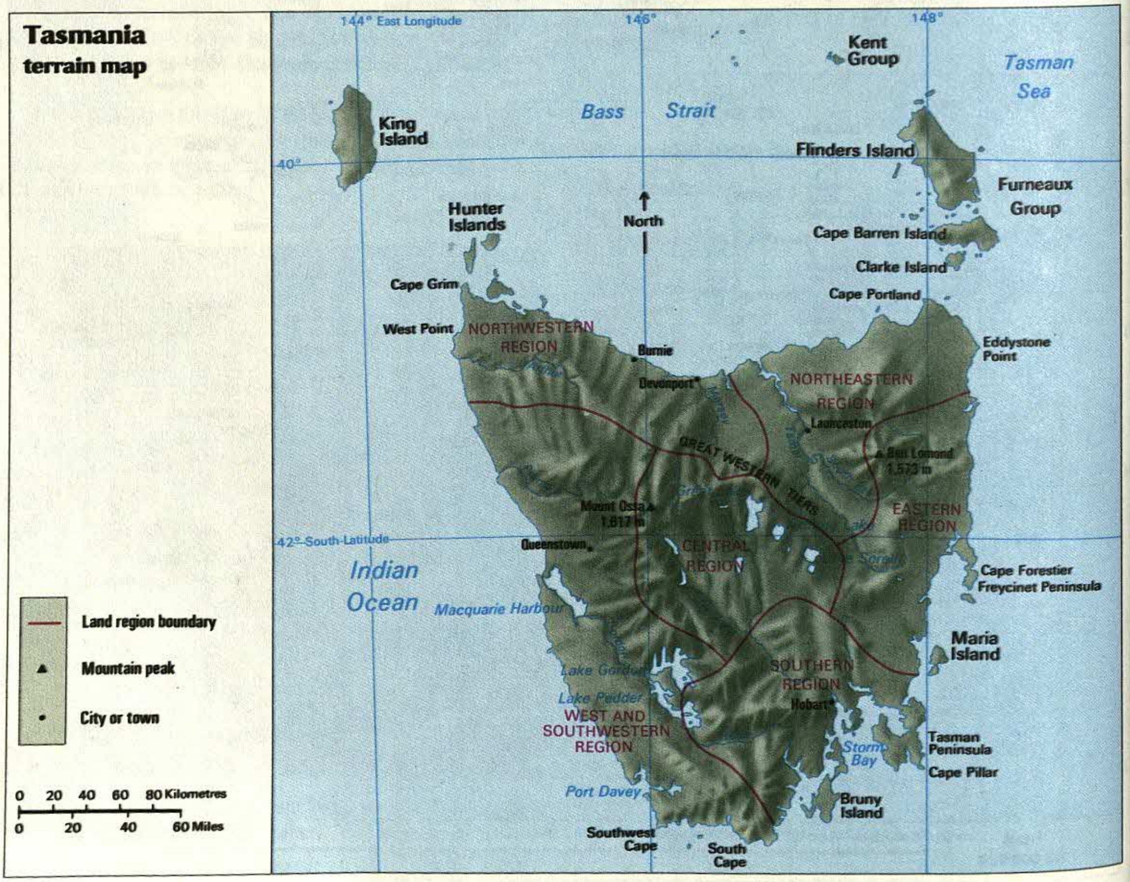
The Central Region includes a large area of the part of Tasmania that consists of a *plateau,* or raised tableland, which slopes from just over 1,000 metres above sea level in the northwest to about 600 metres in the southeast. This area is known as the *lake country* and is one of the chief sources of hydroelectric power. The lake country area contains Tasmania's highest mountain, Mount Ossa. This peak rises 1,617 metres above sea level. The surrounding area is flat and exposed. In some places, glacial scars can be seen. A number of high mountains are located on the western and northern fringes of the region. These mountains include Barn Bluff (1,559 metres), Mount Pelion West (1,554 metres), and Cradle Mountain (1,554 metres).

The Northeastern Region is around Launceston and the Tamar Valley. The biggest plain in the island is in the Tamar rift valley, which stretches from the northeastern edge of the central plateau to the drowned inlet of the Tamar estuary and Port Sorell. This region is one of the richest farming and grazing lands in the state. The northeastern part, which includes Scottsdale, is hilly but has fertile soil.

The Eastern Region includes a mountainous area that contains several tall peaks. Legges Tor (1,573 metres) is the highest peak in the large Ben Lomond mountain mass. Nearby is another high peak, Stacks Bluff (1,527 metres). This mountainous region is very popular among skiing enthusiasts.

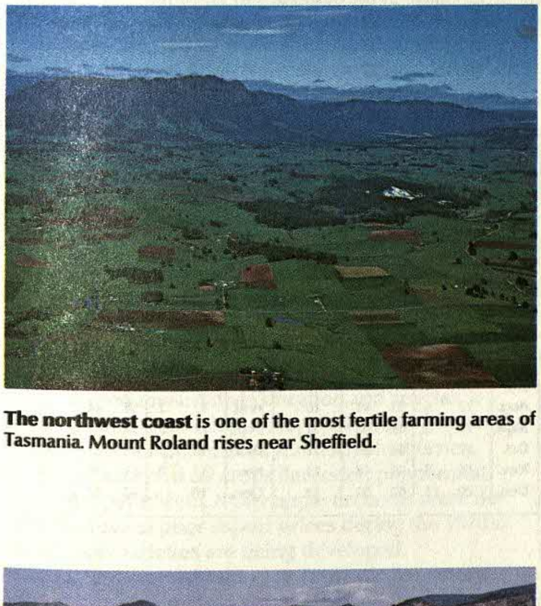
The Northwestern Region has some of the richest soil in the state. This region consists of a narrow coastal plain that rises sharply to a plateau about 610 metres above sea level. The rich, chocolate-coloured soil comes from weathered basalt that resulted from volcanic action a long time ago.

The West and Southwestern Region consists of rugged, broken country studded with mountain ranges, with button grass and heath in between.

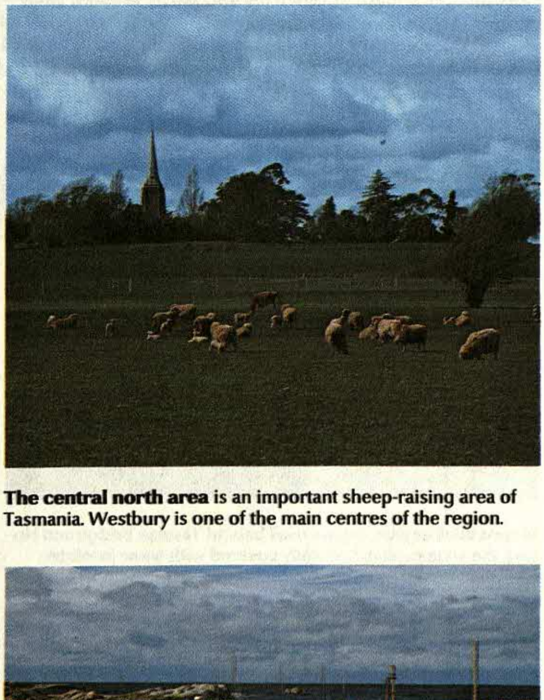


Tasmania
terrain map

Central Tasmania surrounds the Great Lake, the largest natural freshwater lake in Australia. Its water is used to produce hydroelectricity. The lake is popular as a resort for fishing and boating.



The northwest coast is one of the most fertile farming areas of Tasmania. Mount Roland rises near Sheffield.



The central north area is an important sheep-raising area of Tasmania. Westbury is one of the main centres of the region.

The west coast has Queenstown as its main centre. Nearby Mount Lyell is one of Australia's largest copper mines.

The east coast of Tasmania is one of the main areas of the state's fishing industry. Bicheno is one of the main ports.

The Southern Region is an area of broken landscape drained by the Huon and Derwent river valleys. The deep estuary of the Derwent River is a drowned river valley.

The land rises sharply from the water's edge at Hobart to flat-topped Mount Wellington (1,270 metres). The east coast is a region of hills that slope eastward from the central plateau. An extensive shallow sea shelf lies off the coast.

Rivers and lakes. The whole island of Tasmania is crisscrossed by a network of short rivers. The longest river in Tasmania is the South Esk River, which is 201 kilometres long. The South Esk and the North Esk join to form the Tamar River. The 185-kilometre Gordon River is on the west coast. The 182-kilometre Derwent River flows from the Central Highlands, past Hobart, to the sea at Storm Bay. The 170-kilometre Huon River is in the south. The Mersey, Forth, and Leven rivers flow to the north coast. The Pieman and Arthur rivers are on the west coast.

The central plateau has several thousand shallow lakes. They include Great Lake (170 square kilometres), Arthurs Lake (64 square kilometres), and Lake Sorell (52 square kilometres). The Gordon River Dam created Lake Gordon (272 square kilometres) and partly created Lake Pedder (241 square kilometres).

Mount Wellington, which rises behind Tasman Bridge and Hobart, the state capital, is usually covered with snow in winter.

Climate

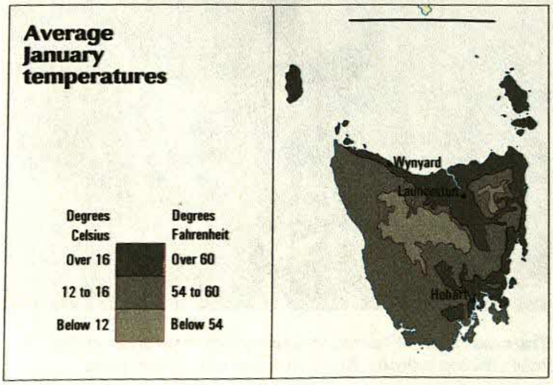
Tasmania has been called the most English of all the Australian states because of its temperate maritime climate. Tasmania has mild winters and cool summers. At Hobart, in the south, the average January temperature is 21° C and the average July temperature is 11° C. Launceston, in the north of the island, is farther inland. It has an average temperature of 24° C in January and 12° C in July.

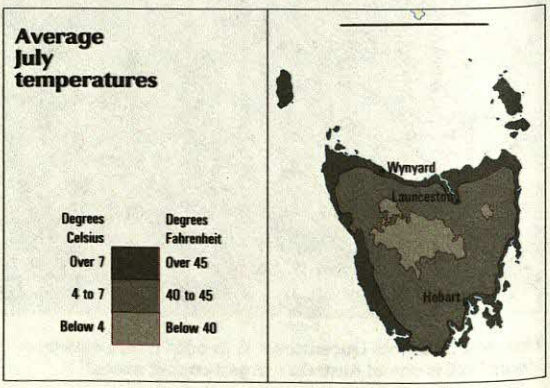
The heaviest snowfalls on the highlands come in late winter and spring, but flurries can occur at any time. Annual rainfall varies considerably. Prevailing westerly winds, known as the *Roaring Forties*, bring heavy rain across the Indian Ocean to the western slopes of the central plateau. Queenstown has about 2,520 millimetres of rain a year. The state's maximum of 3,708 millimetres occurs at Lake Margaret. At Hobart, the annual rainfall is 628 millimetres, and at Launceston, about 708 millimetres. Rainfall lessens towards the east. There is a distinct rainshadow east of the Central Plateau. Parts of the Midlands average less than 500 millimetres of rain a year. The lightest annual rainfall in the state occurs at New Norfolk, which averages 407 millimetres.

The west coast has only about 1,750 hours of sunshine a year, making it the area with the least sunshine in Australia. The northern Midlands area receives the most sunshine in the state, about 2,500 hours a year. Hobart receives about 2,100 hours.

Average monthly weather

Hobart						Wynyard					
	Temperatures				Days of rain or snow		Temperatures				Days of rain or snow
	C°		F°				C°		F°		
	High	Low	High	Low			High	Low	High	Low	
Jan.	22	12	71	53	11	Jan.	20	12	68	54	4
Feb.	22	12	71	53	10	Feb.	20	13	69	55	5
Mar.	20	11	68	51	11	Mar.	19	12	66	53	9
Apr.	17	9	63	48	12	Apr.	17	10	62	50	10
May	14	7	58	44	14	May	14	9	58	48	11
June	12	5	57	41	15	June	12	7	54	45	11
July	12	4	53	40	15	July	12	7	53	44	12
Aug.	13	5	55	41	16	Aug.	12	7	54	44	11
Sept.	15	6	59	43	15	Sept.	14	8	57	46	11
Oct.	17	8	62	46	17	Oct.	16	8	60	47	10
Nov.	18	9	65	48	14	Nov.	17	9	63	49	7
Dec.	20	11	68	51	13	Dec.	19	11	66	52	7





Natural resources. Tasmania is rich in mineral deposits. It also has plentiful supplies of water, rich soil, and extensive forests.

Tasmania is a mountainous state. Only in the far northwest and northeast and in the Tamar-Midlands are there plains of any size. In the northwest, the rich red soil has come from weathered basalt. Since the first settlers cleared the land of its heavy timber covering, this area has had high crop yields. Large areas of swamp land near Smithton have been drained, and their humus-enriched soil has been brought into production.

Considerable parts of the central plateau are covered with moor and sedgeland. Much of the area is exposed, and has peaty soil with poor drainage. Trees of any size are few. In sheltered valleys there are stands of milling timber. Where the rainfall and soils are suitable, there are areas of dense rain forests, mainly in the south, west, northeast, and northwest. Drier parts, such as the midlands and much of the east coast, have much open forest or lightly timbered stretches. In the forested west coast, bands of horizontal scrub are hard to penetrate.

Farming. The northwest coast, with its fertile soil and annual rainfall of often more than 1,000 millimetres, is an area of intensive farming. It produces dairy products, beef cattle, pigs, potatoes, peas, beans, and hay.

Throughout Tasmania, the production of cattle and sheep for meat has led to an increase in the amount of land sown to pasture. Apart from the northwest, other areas rich in dairy products are the northeast and St. Marys district. Beef production is high in the same places. The pastoral districts of the central north and northern midlands produce large quantities of sheep and cattle. Goats are raised for dairy products and for mohair. Several deer farms have been established. The midlands area yields some of the best wool in Australia. Most of Australia's hops are grown in Tasmania, mainly in the Derwent Valley, in the northeast around Scottsdale, and at Gunn's Plains. Other important crops include barley, wheat, hay, potatoes, green peas, apples, small fruits, onions, and legumes. In recent years there has been a trend toward diversification and specialization of crops and products. Farmers have been growing opium poppies (for pharmaceutical use), blueberries, wine grapes, essential oil crops (lavender, peppermint, aniseed), and pyrethrum. Many apple orchards were destroyed because of poor export prices during the 1970's. But today, new varieties are being developed.

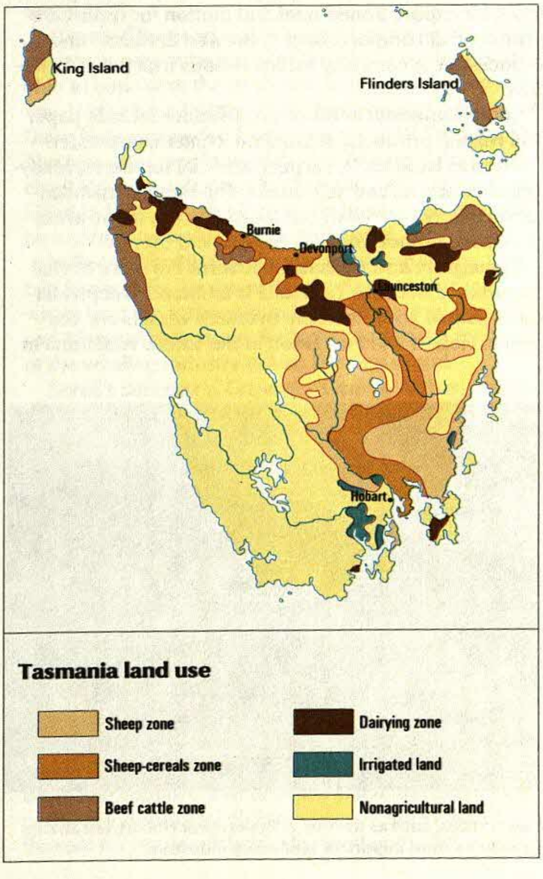
Fishing. Commercial fishing in Tasmania has seen a significant growth in recent years. Aquaculture has become an important part of the diversifying industry. Such species as the Atlantic salmon, sea run trout, oysters, mussels, sea urchins, and abalone have opened up lucrative overseas markets. Tasmania has about 1,000 licensed fishermen, harvesting almost 70,000 metric tons of fish for export each year. The main fishing ports are Bridport, Stanley, and Smithton in the north; Bicheno, St. Helens, and Triabunna in the east; and Hobart, Dover, and Kettering in the south. Strahan on the west coast is noted for lobsters.

Forestry. Forest-based industries provide employment for one in seven Tasmanians. Nearly half the island is forested, mainly with such hardwoods as eucalypts. The main commercial forests are in the northwest, northeast, and southern parts of the state. Unlike other Australian states, Tasmania has a complete range of native forest-based industries, from woodcraft to wood fuels. Tasmanian companies produce veneer, timber, woodchips, pulp newsprint, and fine paper. Paper and hardboard are produced at Burnie, and chipboard and paper at Wesley Vale. A mill on the Derwent River, at Boyer, is one of two mills producing newsprint in Australia. Wood pulp pellets are produced in the Huon Valley. Timber unsuitable for milling is made into woodchips for export to Japan.

Mining is an important industry in the economy of Tasmania. The mountainous west coast is one of the most mineral-rich areas in Australia. It has copper, tin, iron, and silver-zinc-lead ore bodies. The largest tin mine in the world is located at Renison Bell in this region. Also in this area are silver-lead-zinc mines at Rosebery, the Que River, and Hellyer. Iron ore is mined at Savage River, and is sent by pipeline in slurry form to Port Latta, on the northwest coast. There, it is formed into pellets for export to Japan. The importance of Mount Lyell, once a major copper mine near Queenstown, declined in the 1980's.

Coal is mined in the Fingal Valley. Scheelite is mined close to Burnie. Large quantities of dolomite and limestone are mined on the northwest coast. Silica for the manufacture of glass is mined in the south.

Power projects. The Hydro-Electric Commission has taken advantage of Tasmania's geography and rainfall to



Tasmania land use

develop cheap hydroelectric power for industries. Water from Lake St. Clair, where the Derwent River rises, may pass through eight power stations before reaching the tidal waters at New Norfolk. A second system uses the waters from the Mersey and Forth rivers and their tributaries to generate power at seven stations. A third system uses the water from the Great Lake that has been directed into the South Esk River system.

The Gordon River Power Development Scheme created Lake Gordon as the biggest water storage facility in Australia. The Pieman River Power Development Scheme developed the Pieman River through a series of lakes and tunnels. This scheme was completed in 1986.

Manufacturing. About one-fourth of the total work force is engaged in manufacturing. The factories produce chemicals, textiles, wood pulp, processed foods, aluminium, industrial equipment, manganese alloys, iron ore pellets, and newsprint.

Factories owned by a single company operate at Edith Creek, Legerwood, Wynyard, and Devonport. They use 70 per cent of the milk produced in the state. The factories manufacture butter, milk powder, casein, bacon, and cheese. Factories at Devonport, Ulverstone, and Scottsdale produce frozen and canned vegetables, while another company at Smithton produces frozen vegetables. Burnie exports cheese to Japan. A factory at Quoiba, near Devonport, is one of the largest Ovaltine factories in the world. A company at Claremont, near Hobart, operates the largest cocoa and confectionery factory in Australia. A company in Devonport slaughters stock for export. Boned beef and mutton for export are produced at Longford. Beer is brewed at Hobart and Launceston. A company makes various fruit juices in Hobart.

Other important items of manufacture include paper and related products, aluminium, cement, textiles, refined zinc, hand tools, carpets, artificial fertilizers, ready-mixed concrete, and soft drinks. The biggest manufacturing centres are nearly all located in the urban areas of Hobart, Launceston, Devonport, and Burnie.

Transport and communications. Ports are of vital importance because Tasmania is an island. Deepwater ports able to accommodate overseas vessels are situated at Hobart and Port Huon in the south; Triabunna in the east; Beauty Point, Inspection Head, Long Reach, and Bell Bay, on the Tamar River, in the north; and Devonport, Burnie, and Port Latta in the northwest.

The Australian National Railways Commission operates 864 kilometres of 1.06-metre line. No passenger service is provided. The main line connects Hobart and Launceston. Almost 90 per cent of state-controlled roads have sealed surfaces.

Air transport is both interstate and intrastate. Interstate air transport of passengers and cargo is provided between Hobart, Devonport, Burnie, and centres in Victoria and New South Wales by Ansett Airlines of Australia, Australian Airlines, and East-West Airlines. Qantas and Air New Zealand operate direct weekly flights between Hobart and the New Zealand cities of Auckland and Christchurch. Airlines of Tasmania operates within the state and to Flinders Island. The main airports are located at Hobart, Launceston, Wynyard, King Island, Flinders Island, and Cambridge. Locally owned airports are at Devonport, Smithton, St. Helens, Queenstown, and Strahan.

Television and radio services are provided by the Australian Broadcasting Corporation and by commercial stations. The three daily newspapers published in the state are the Hobart *Mercury,* the Launceston *Examiner,* and the Burnie *Advocate.*

Paper mills, such as the one at Boyer, near Hobart, are among Tasmania's most important secondary industries.

Hydroelectric power stations, such as the one at Tarraleah, in central Tasmania, are of vital economic importance.

Port Arthur, on the Tasman Peninsula in southeastern Tasmania, was a penal settlement for convicts from 1833 to 1877.

Tasmania was known officially as *Van Diemen's Land* until 1856. It was named by the Dutch navigator Abel Janszoon Tasman, on Nov. 24, 1642, after Anthony Van Diemen, Governor of Batavia (now Jakarta), who had commissioned his voyage of exploration. Many later explorers landed at or near the mouth of the Derwent River. When Marion du Fresne, a French captain, visited Frederick Henry Bay in 1772, the first violent exchange between Europeans and the Aborigines on the island took place. Tobias Furneaux, James Cook's lieutenant, visited Adventure Bay in 1773, and Cook himself landed in the same place in 1777. Bruni d'Entrecasteaux, a French navigator, discovered D'Entrecasteaux Channel in the Derwent in 1792.

The existence of Bass Strait, separating the island from the Australian mainland, was confirmed by the voyages of George Bass and Matthew Flinders in 1798. In 1802, while charting the southern Australian coast, Flinders met the French explorer Nicolas Baudin in Encounter Bay.

Governor Philip Gidley King of New South Wales was anxious to forestall any French colonization in the area. British officials arranged for settlers to be sent to Port Phillip on the mainland coast of the strait while King's main party went to the Derwent River in the south of the island. A party of 49, led by Lieutenant John Bowen, landed at Risdon, on the Derwent, in September 1803. Eber Bunker, captain of the whaler *Albion,* landed Bowen's party. During Bowen's absence, when the camp was under the command of Lieutenant Moore, a party of Aborigines approached. The settlers panicked and fired on the Aborigines, killing a number of them.

A month after Bowen's landing, David Collins landed at Port Phillip. But he found the area unsuitable and moved to Risdon on Feb. 15, 1804, taking command. He soon moved the settlement from Risdon to the present site of Hobart. Meanwhile, settlement began in the north. Governor King received instructions issued a year earlier from England, and sent Lieutenant Colonel William Paterson to found a colony along the northern coast. Paterson landed at Port Dalrymple, on the Tamar River, late in 1804. He called his settlement *York Town.* But it was soon abandoned for George Town, which was abandoned in favour of the present site of Launceston in 1806.

Thomas Davey, who succeeded Collins as lieutenant governor, was quite unsuited for the post. He was unable to cope with the problems of the developing colony. Under his administration, bushranging became rife. Davey was succeeded by the energetic William Sorell. The new governor hunted the bushrangers down. Michael Howe, a notorious bushranger, was captured and killed in 1818. After his death, the bushrangers ceased to be a serious menace. See **Bushrangers.**

In December 1815, a pioneer whaler-explorer, Captain James Kelly, explored the southwest coast in a whale boat. He is thought to have discovered Port Davey and Macquarie Harbour. Kelly was one of the founders of the whaling industry in Van Diemen's Land.

Sorell's successor, Governor George Arthur, became alarmed when more than 30 settlers were killed by Aborigines in 1830. He decided on a desperate and unsuccessful measure, the so-called *Black War.* More than 3,000 men formed the *Black Line* to drive the Aborigines onto Tasman Peninsula. Only two Aborigines were caught. The rest evaded the line. None were killed. George Augustus Robinson proposed conciliating the Aborigines. The Aborigines were placed on a series of small islands and were finally gathered together on Flinders Island in November 1831. When Robinson himself took charge in 1835, there were only 123 Aborigines at the settlement. Despite his best efforts, they all died, mainly from European diseases. Truganini, who has been generally claimed as the last tribal Tasmanian Aborigine, died in 1876. But recent evidence discounts this claim and supports that of Fanny Cochrane Smith, one of the few Aboriginal children born at the Wybalena settlement on Flinders Island. She lived until 1905.

From 1830 onward, Governor Arthur and his successors had increasing difficulty in reconciling the convict system with the developing free settlement. A pastoral enterprise, the Van Diemen's Land Company, was formed in 1825 to take up a huge land grant. It paid its first dividend in 1834. Under the direction of Edward Curr, manager of the company, the surveyors Joseph Fossey, Henry Hellyer, Clement Lorymer, and the colourful Danish adventurer Jorgen Jorgenson, undertook pioneer exploration in the rugged, remote, northwest corner of the state during 1826 and 1827. In 1830, Michael Fenton established an estate called *Fenton Forest*, where he introduced the island's first irrigation system. In 1832, John Cox introduced the first coach service between Hobart and Launceston. Meanwhile, such northern Tasmanian *overstraiters* (people who moved from Tasmania to mainland Australia across Bass Strait) as Thomas Henty, John Batman, and John Fawkner were refounding Port Phillip as a boom settlement.

The great majority of convicts were assigned to settlers, a system introduced by Governor King of New South Wales in 1804. In this system, the settler got free labour from the assigned convict in return for providing rations, clothing, and housing. With good conduct, a convict could progress to the status of *ticket-of-leave*—a type of parole allowing the convict to work for wages within a limited area. A convict could then gain a pardon conditional on his or her remaining within the colony and, finally, a full pardon.

In 1832, out of 11,000 convicts, about 6,400 were assigned in private service; 1,650 were assigned in public service; almost 1,200 had tickets; more than 500 were in chain gangs; nearly 200 were in the severe detention centre at Macquarie Harbour; and 240 were on the new penal settlement at Port Arthur.

Macquarie Harbour penal settlement was established by Governor William Sorell in 1821 as a place of isolation for the most hardened convicts. Prisoners there cut much timber for shipbuilding in Hobart. The rugged country around Macquarie Harbour made escape dangerous. Only 62 out of 112 prisoners who managed to escape from this penal settlement are recorded as having survived. At Port Arthur, the system was also severe, but it was directed toward the reform of convicts.

Unfavourable feelings toward the convict system intensified in 1842, when assignment to private citizens stopped. Matters came to a head in 1845, when the British government instructed Governor Sir John Eardley-Wilmot that Van Diemen's Land should bear a greater cost of the convict system. The nonofficial members of the Legislative Council, led by Richard Dry, refused to vote on the estimates, and walked out of the meeting. For this act they were acclaimed as the *patriotic six*. Transportation of convicts to Van Diemen's Land was finally abolished in 1853, after the antitransportation movement had rallied Australian opinion. In all, about 70,000 convicts—57,000 males and 13,000 females—were transported to the island.

Although the name *Tasmania* was in popular use as early as 1844, it was not officially substituted for Van Diemen's Land until 1855. In that same year, Tasmania became the first of the Australian colonies to have its constitution approved. The first state premier was William Champ.

For the next 50 years, Tasmania was troubled by periodic economic depressions. The great mineral discovery of the period was of tin, by the prospector Philosopher Smith, at Mount Bischoff in 1871. Copper was discovered at Lyell in 1883. The Electrolytic Zinc Company was established at Risdon in 1917.

In 1909, a company was granted a concession to generate hydroelectricity at the Great Lake. In 1914, it was taken over by the state and the Tasmanian Hydro-Electric Commission was formed. Cheap electricity spurred industrial growth. But in the 1970's, the building of the Gordon River Dam was opposed by conservationists because it involved flooding Lake Pedder. The scheme was completed in 1976 despite this opposition. But in the 1980's, the Australian federal government intervened to stop the building of another dam across the Gordon River that would have involved flooding the Franklin River wilderness area.

Despite the various drifts to the mainland, Tasmania's population grew steadily. From nearly 90,000 in 1860, it rose to 172,900 by 1900. It reached 390,000 in the 1970's and passed 400,000 in the 1980's.

Related articles in *World Book* include:

Biographies

Arthur, Sir George
Bass, George
Bowen, John
Brady, Matthew
Cash, Martin
Collins, David
D'Entrecasteaux, Bruni
Dry, Sir Richard
Du Fresne, Marion
Flinders, Matthew
Knopwood, Robert
Lanney, William
Lyons (family)
Robinson, George Augustus
Tasman, Abel Janszoon
Truganini
Wedge, John Helder

Cities and towns

Burnie
Devonport
Hobart
Launceston
Port Arthur

Outline

- **I. Government**
- **II. People**
- **III. Education**
- **IV. Visitor's guide**
- **V. Land**
  - A. Location and size
  - B. Land regions
  - C. Rivers and lakes
- **VI. Climate**
- **VII. Economy**
  - A. Natural resources
  - B. Farming
  - C. Fishing
  - D. Forestry
  - E. Mining
  - F. Power projects
  - G. Manufacturing
  - H. Transport and communications
- **VIII. History**

Questions

Why has Tasmania been called the most English of Australian states?
By what name was the island officially known before it was renamed Tasmania?
What natural processes caused the soil of the Northwestern Region to be the richest in the state?
Why were many Tasmanian apple orchards destroyed during the 1970's?
In what way is Tasmanian forestry unlike that of other Australian states?
Why were the *patriotic six* so named?
What are the *Roaring Forties*?
For what purpose was the Van Diemen's Land Company formed?
Where are Tasmania's biggest manufacturing centres located?

Tasmanian Aborigines had to adapt to the cold climate of Tasmania. They covered their bodies with a mixture of fat, ochre, and charcoal. Women wore kangaroo-skin cloaks.

Tasmanian Aborigines of today are mostly descended from the tribal Aboriginal women who were taken from Tasmania to nearby islands in Bass Strait by European sealers in the early 1800's. There are about 5,800 Tasmanian Aborigines. They live throughout Tasmania, but communities are concentrated in Hobart, Burnie, Launceston, and the Bass Strait Islands.

Aborigines in Tasmania, like those all over Australia, are seeking to keep a close attachment to their traditions and culture. They consider the land as an essential part of their physical, emotional, and spiritual wellbeing. Aboriginal land claims in Tasmania include all rock-carving and rock-art sites, Oyster Cove, Cape Barren Island and all other mutton-bird breeding islands, and Cape Grim—the site of a massacre in 1830.

Traditional life

In traditional times, the Tasmanian Aborigines were a healthy, friendly people. Their technology, though simple, was extremely efficient. Their detailed knowledge of the seasons and the environment produced an adaptable, dynamic culture.

Clothes and ornaments. Both men and women protected their bodies from the cold, damp winters with a mixture of fat, ochre, and charcoal. Kangaroo-skin cloaks were worn by the women and occasionally by the men. Children went naked. Both men and women wore necklaces made of shells, kangaroo sinews covered with ochre, and strips of animal fur.

All men and women were decorated with scars on their shoulders, arms, chest, back, stomach, and buttocks. These line and circle designs may have been *badges* showing membership of different bands or tribes. Women generally cropped their hair short while men from some tribes grew their hair and coated each lock with grease and ochre.

Food. Throughout Tasmania, the most important foods were kangaroos and related animals and plant foods such as fern roots, fungus from the grass tree, and some berries. Seal, crayfish, and shellfish—including abalones, oysters, and mussels—were a main part of coastal people's diet. The amount of these foods eaten by the Aborigines depended upon their needs and living patterns, and the availability of the food resource. The Aborigines cleared the land with fire so that they could travel more easily. Animals were attracted to these areas due to the new growth. The Aborigines also managed the land by moving from an area before eating all available food. No direct evidence suggests that Tasmanian Aborigines could make fire. Instead, they kept a slow-burning firestick alight at all times.

Tools. The Tasmanians made tools and containers from wood, bone, stone, seaweed, bark, grass, and animal sinews or tendons. Choppers, scrapers, knives, planes, and sawlike flakes were made from the fine-grained stones found throughout Tasmania. Spears and clubs were mostly made from teatrees.

Women used blunt wooden blades to prise shellfish from rocks. They used digging sticks for collecting roots and fungi. They also made baskets from *juncus* reed.

Shelters were made from two basic designs. Temporary windbreaks made of branches and bark were used in the northeast and east. In the colder, windier regions of western and central Tasmania, dome-huts were made of branches, thatched grass, and bark. They were warm, comfortable dwellings lined with feathers.

Watercraft. Islands as far as 25 kilometres offshore were visited as seasonal foods, such as seals and mutton-birds, became plentiful. Watercraft were made of three rolls of bark and seaweed with reeds or grass. A full-sized craft measured about 3 metres in length.

Social organization. There were three levels of social organization among the Tasmanian Aborigines. First was the *hearth group,* which included a husband and wife, their children, and other relations. This group cooked and camped around a single fire. On the west coast, they shared a hut. The second level was the *band,* the basic landowning group, which consisted of several hearth groups. The food supply determined the size and number of the bands. The band was led by an older man who was an outstanding hunter or warrior. One band could admit or deny other bands foraging rights in its particular territory. The *tribe* was the third level. Aboriginal Tasmanians were grouped into nine tribes, ranging in size from 250 to 700 people. Each tribe was made up of a number of bands that lived in adjoining territories, spoke the same language or dialect, and shared the same cultural traits.

Seasonal movement and trade. During the year, bands from the nine tribes moved across the bounda-

Tasmanian Museum and Art Gallery

Woureddy, a Tasmanian Aborigine, was painted by Thomas Bock in 1837. Woureddy was the husband of Truganini, perhaps the last tribal Tasmanian Aborigine.

ries of one or more of their neighbours, mainly to exploit different food resources. Ochre, shells, shell necklaces, and good stone for tools were the items most commonly traded and exchanged as different bands came into contact with one another.

Religion. The Tasmanian Aboriginal religion shared many common features with mainland Aboriginal religion. Good and bad spirits were associated with creation, fire, rivers, trees, and the dead. The Tasmanian Aborigines had totems and associated taboos. They told many stories about how the world and all the animals and plants were created.

Disposal of the dead. The Aboriginal people used four different methods to dispose of their dead. Each tribe used one of the four methods. In many areas, the body was cremated and the bones and ashes usually collected and buried. This seems to have been the most common method. Some tribes buried the body in a shallow grave in dune sand or soft earth, lying on its side with its knees pulled up to its chin. Others placed the body in a hollow tree and covered it with sheets of bark. The body might later be burned. A fourth method was to bury the body in a tomb formed of bark. The Aborigines considered it taboo to mention a dead person's name or to return to the person's burial place. Small bones of the dead were often worn as mementos and as charms.

Art. Before 1986, it was always thought the Tasmanian Aborigines produced only rock carvings, charcoal drawings, and stone alignments. To create these, the Aborigines used geometric designs that combined circles, lines, and dots. However, recent findings in southwest Tasmania have revealed highly significant ochre hand stencils on the walls of a limestone cave in the Maxwell River Valley. This new evidence confirms that Aboriginal Tasmanians definitely produced painted art. Stencils found in southeast Tasmania were previously thought to have been painted by Sydney Aborigines.

Language. Most researchers agree that there were at least five related languages or dialects. Unfortunately, the Tasmanian languages survive only in word lists, Tasmanian place names, and several recorded songs.

Song and dance. Singing and dancing were extremely important in Tasmanian Aboriginal society. Songs and dances told stories about creation, war, love, the beauties of nature, and important people and events. Women often sang in three-part harmony, and they accompanied themselves by beating two sticks together or by drumming on rolled-up kangaroo skins.

History

Archaeological evidence shows that the Tasmanian Aborigines settled in the southeastern tip of the Australian mainland at least 23,000 years ago. This area is now known as Tasmania and is separated from the mainland by Bass Strait. At the time of the first human settlement, average temperatures in the area were lower than they are today. The Ice Age environment was generally drier as well, with mountains covered in snow and ice throughout the year. With the general warming of the world's climate about 15,000 years ago, the Bassian land bridge flooded to become Bass Strait. By about 12,000 years ago, the Tasmanians became an isolated people. However, anthropologists believe they had a close physical and cultural affinity with the Australian Aborigines.

The arrival of the Dutch explorer Abel Tasman in 1642 marked the beginning of European contact with the 4,000 or so Tasmanian Aborigines. In 1771, the French explorer Marion du Fresne became the first European to meet the Tasmanians. But a misunderstanding led to fighting in which several men from both sides were wounded. During the next 30 years, more explorers—including Cook, D'Entrecasteaux, and Baudin—visited Tasmania's shores. Most had friendly meetings with the Aborigines. After the first settlement in 1803, however, grave misunderstandings and disastrous events severely altered the life style of the tribal Aboriginal people. Within 30 years of white occupation, only 135 tribal Aborigines remained. As a result of unsuccessful settlements at Wybalenna on Flinders Island and at Oyster Cove, most of these people had died out by 1876.

A new Aboriginal community was growing during this period. In the early 1800's, European sealers had stolen tribal Aboriginal women to hunt wallabies and capture seals in the Bass Strait Islands. By the 1850's, the sealers and Aboriginal women had married. Muttonbird harvesting became the mainstay of the community. Together, the men and women built a life style that was based on both traditional Aboriginal ways and European ways.

For many years, Tasmania's government and white community ignored these people. Today, Tasmania's Aboriginal people are fighting for the recognition of their existence and their rights.

See also **Lanney, William; Robinson, George Augustus; Smith, Fanny Cochrane;** and **Tasmania.**

Tasmanian devil is a fierce animal that lives on the Australian island of Tasmania. It eats small mammals and reptiles, plus any dead animals it can find. It hunts mainly at night and spends the day in a cave, a hollow log, or some other shelter. Tasmanian devils measure about 1 metre long, including a tail of about 30 centi-

The Tasmanian devil, a fierce animal of the Australian island of Tasmania, hunts small mammals and reptiles at night.

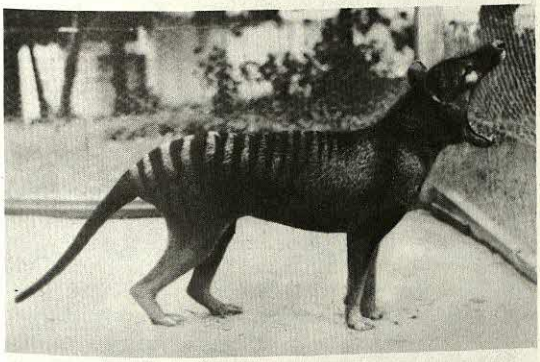
metres. Most have black fur with white markings, but some are entirely black. Tasmanian devils are *marsupials.* Female marsupials give birth to tiny, poorly developed offspring. Like most marsupials, young Tasmanian devils are carried in a pouch on the mother's belly, where they feed on her milk until they develop more completely.

Scientific classification. The Tasmanian devil belongs to the marsupial family Dasyuridae. It is *Sarcophilus harrisii.*

Tasmanian tiger, also known as *thylacine,* or Tasmanian wolf, was a large animal of the Australian island of Tasmania. Most scientists believe it is extinct. The Tasmanian tiger measured about 1.5 metres long, including a tail of about 50 centimetres. It had short brown fur and looked like a wolf. Dark stripes resembling those of a tiger crossed the rear part of its back.

The Tasmanian tiger was a *marsupial.* Female marsupials give birth to tiny, poorly developed young. Like the offspring of most living marsupials, young Tasmanian tigers were carried in a pouch on the mother's belly, where they fed on her milk until they developed more completely. Tasmanian tigers were fairly common until the early 1900's. European settlers hunted them—and probably killed them off—because the animals preyed on sheep and poultry.

Scientific classification. The Tasmanian tiger makes up the marsupial family Thylacinidae. It is *Thylacinus cynocephalus.*



The Tasmanian tiger, which most scientists believe is extinct, had stripes along its back like those of a tiger. The photo above, taken in 1933, shows the last Tasmanian tiger in captivity.

Tass is an important news agency in Russia. Its full name is Itar-Tass. It distributes information to newspapers around the world. The agency obtains news by means of a worldwide network of reporters and editors. Itar means Information, and Tass is an abbreviation of *T*elegrafnoye *A*gentstvo *S*ovietskovo *S*oyuza (Telegraph Agency of the Soviet Union). The name Tass has been retained even though the Soviet Union was dissolved in 1991.

Until 1991, Tass was the official news service of the Soviet Communist Party. Tass transmitted news of party conferences, meetings, and discussions. Agency editors had to be approved by party committees. Most editors were party members.

Tass was formed in 1925 as a reorganization of the Rosta Agency. Rosta had begun operating in 1918, replacing the czar's information service.

See also **News service.**

Tasso, Torquato (1544-1595), was an Italian poet of the late Renaissance period. He was long connected with the court of Alfonso II, Duke of Ferrara. Tasso was one of the greatest masters of Italian poetry. He took full advantage of the sonorous beauty of the language, and gave his poems a gently mournful mood. His pastoral drama, *Aminta* (1573), concerns the victory of true love over base love in a fantasy world of loyal shepherds.

Tasso's masterpiece was his *Jerusalem Delivered* (1575), an epic about the first crusade and the delivery of the sacred tomb from the infidels. It is written, like Ludovico Ariosto's *Orlando Furioso,* in melodious, eight-line stanzas. It is more compact and regular than Ariosto's epic, though it is filled with valiant warriors, noble heroines, enchantresses, miracles, and dire dangers. But Tasso restrained his epic. He feared that the Roman Catholic Church might censor it because of its sensuousness and its evidence of pagan mythology.

Tasso's natural inclination toward morbidity finally induced him to rewrite his epic under the title of *Jerusalem Conquered* (1593). Tasso became mentally ill in 1576, and from 1579 to 1586 he was confined in an asylum for the insane. Tasso was born in Sorrento, Italy.

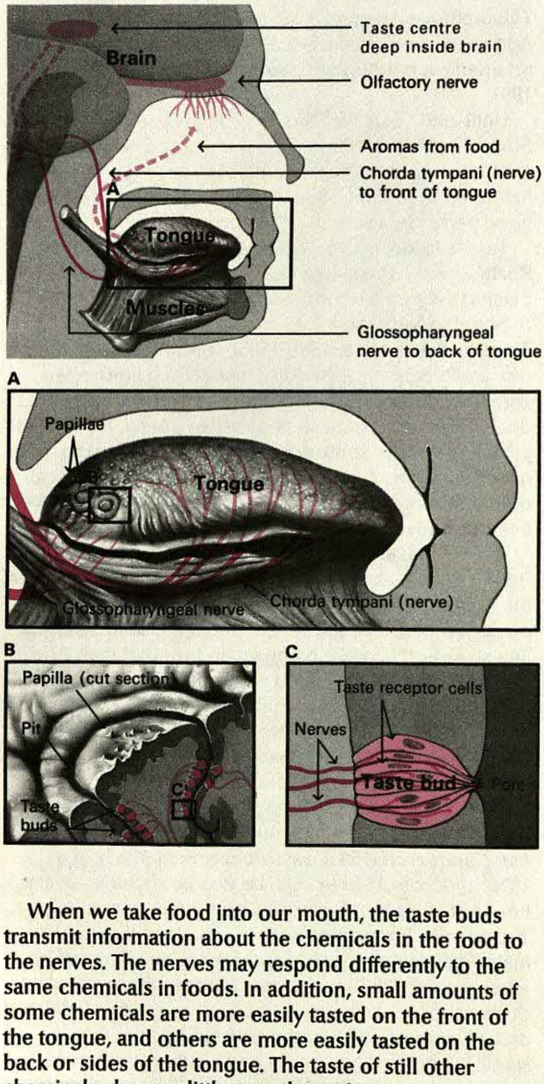
Taste is an important sense in people and many animals. The taste of foods helps determine what and how much we eat. People may reject foods whose taste they dislike and as a result may not have a properly balanced diet. Our sense of flavour is affected by how things smell. When we have a cold and a stopped-up nose, some foods may taste alike (see **Smell**). Food must be moist to be tasted. If the tongue and food are dry, there is no taste.

Many people believe that there are four kinds of taste—salt, sour, sweet, and bitter. But the *receptor cells* that make up our *taste buds* do not have structural or functional differences that correspond to these tastes. The idea of the four categories of taste seems to be something that is learned. Taste categories may be only easily identified characteristics of taste. They tell us little about how the taste sense functions.

Taste buds are grouped on the tongue into small mounds called *papillae.* The papillae on the front part of the tongue have their taste buds connected to one nerve. The papillae on the edges of the tongue—about halfway between front and back—and those at the back of the tongue are connected to a second nerve.

How taste works

The sense of taste is sent to the brain through taste buds located in the tongue. In the diagrams below, each boxed-in section is enlarged in the following drawing.



When we take food into our mouth, the taste buds transmit information about the chemicals in the food to the nerves. The nerves may respond differently to the same chemicals in foods. In addition, small amounts of some chemicals are more easily tasted on the front of the tongue, and others are more easily tasted on the back or sides of the tongue. The taste of still other chemicals changes little over the entire tongue.

The nerves from the papillae come together at the back part of the brain stem. Here, some taste signals carried by the nerves are separated according to the different chemicals they respond to. The taste signals then travel to the front of the brain stem, the *thalamus.* From the thalamus, the signals move to the *cerebral cortex* of the brain. Here, the signals are interpreted, and we become aware of taste.

The receptor cells that make up the taste buds are continually being replaced. The receptor cells develop from skin cells that surround the taste buds. The skin cells slowly move into the area of the taste buds. As the skin cells move, they turn into receptor cells. About half the receptor cells are replaced every 10 days.

Tata is the name of a family prominent in the industrial and commercial life of India.

Jeejibhoy Jamshedji Tata (1783-1859) was a leading industrialist. He was born into a poor Parsee family in the princely state of Baroda. He made a fortune in the export business through commercial insight and hard work. He also started the family tradition of giving generously to charity.

Jamshedji Nasarwanju Tata (1839-1904), the son of Jeejibhoy, greatly expanded the business empire left by his father. He did much to develop India's cotton, power, and steel industries. He also donated money to set up the Indian Institute of Science at Bangalore. He was born at Navarsi, Gujarat.

Jehangir Ratanji Dadabhoy Tata (1904-1993) became chairman of the Tata group of companies in the 1930's. He founded Tata Airlines in 1932, and became chairman and member of the board of Air India from 1946 to 1978. He was born in Paris.

Tatars are a Turkic-speaking people of Europe and Asia. Most Tatars live in the central and southern parts of Russia and in Bulgaria, China, Kazakhstan, Romania, Turkey, and Uzbekistan. The Tatars are Turks, and they are related to the people of Turkey. Typical Tatar groups living in Russia and central Asia include the Crimean Tatars, the Siberian Tatars, and the Volga Tatars. Most of the Tatars are *Muslims* (followers of Islam).

The Tatars are sometimes called *Tartars.* During the 1200's they joined with other Mongol tribes and neighbouring nomads to invade eastern Europe. Today, there are more than 6 million Tatars. They are no longer nomadic. More than $1\frac{1}{2}$ million of them live in the Tatar republic in Russia. Kazan, the capital of the Tatar republic, is a centre of Tatar culture (see **Kazan**).

Tate, Allen (1899-1979), was an American poet and critic. Many of his writings express dislike for the dehumanizing way of life in modern society.

Tate is best known for his poetry, much of which is powerful, intense, and written in violent language. His *Collected Poems: 1919-1976* was published in 1977. Many of his critical works were published in *Essays of Four Decades* (1969). Tate included both critical and autobiographical essays in *Memoirs and Opinions* (1975).

John Orley Allen Tate was born in Winchester, Kentucky, U.S.A. As a student, he helped found the Fugitives, a group of Southern writers who hoped to preserve the cultural heritage of the South.

Tate, Maurice (1895-1956), was an England and Sussex all-round cricketer. He first played for Sussex in 1911, at the age of 17. Tate achieved the double of 1,000 runs and 100 wickets in eight consecutive seasons, from 1922 to 1929. In 1923, 1924, and 1925, he took more than 200 wickets in each season. Tate was born in Steyning, West Sussex, England.

Tate, Nahum. See **Poet laureate.**

Tate Gallery, in London, houses an outstanding collection of paintings and sculptures by both British and other artists. The painting collection represents the work of British artists from the 1500's to the present and of artists from other countries since the late 1800's. The Tate Gallery in Liverpool houses paintings from the 1900's. The Tate Gallery is particularly noted for its paintings by the English artists J. M. W. Turner and William Blake, and the Pre-Raphaelites. The collection of modern sculptures includes works by Auguste Rodin and Henry Moore. Special exhibitions are held frequently.

The foundation of the Tate Gallery was almost entirely the result of private gifts made by individual people. In 1841, the sculptor Sir Francis Chantrey left a large fortune to form a national collection of British art. In 1890, Henry Tate, who later became Sir Henry Tate, offered his own collection of pictures and £80,000 for a new building to house the growing collection. Eventually a site was found at Millbank, on the Thames Embankment. In 1897, the Prince of Wales, the future King Edward VII, opened the new gallery. Until 1955, it was supervised by the trustees of the National Gallery. The art historian Sir John Rothenstein was director from 1938 to 1964. Subsequent directors were Norman Reid; Sir Alan Bowness, from 1980; and Nicholas Serota, from 1988. Queen Elizabeth II opened extensions to the Tate Gallery in 1979 and 1987. In 1988, a new gallery opened in Liverpool.

Tattooing is the practice of making permanent designs on the body. It is done by pricking small holes in the skin with a sharpened stick, bone, or needle that has been dipped in pigments with natural colours.

Tattooing is one of the oldest forms of creative expression. Cave paintings date it to at least about 8000 B.C. Almost every culture has practised tattooing. The ancient Greeks and Romans used tattoos to brand slaves and criminals. Tattooing was sometimes banned among Jews and Christians.

Tattoos were a sign of honour and new status in the Marquesas Islands, a group of islands in the South Pacific Ocean. The people of eastern New Guinea regarded tattoo marks on young women as signs of beauty. Today in the Western world, some people have tattoos to gain membership into a particular group or to change social status. For other people, tattoos are works of art. Still others have them to express patriotism, devotion to loved ones, or religious convictions.

There are some health risks associated with tattooing, primarily the danger of spreading infectious diseases if sterile conditions are not maintained during the tattooing process. Tattoos can be removed with *lasers* (intense light beams).

Tatum, Art (1909-1956), ranks among the greatest piano soloists in the history of jazz improvisation. Tatum's light and delicate touch and swinging beat were perhaps unequalled among pianists of his time. His brilliant keyboard technique earned him the praise of many classical pianists.

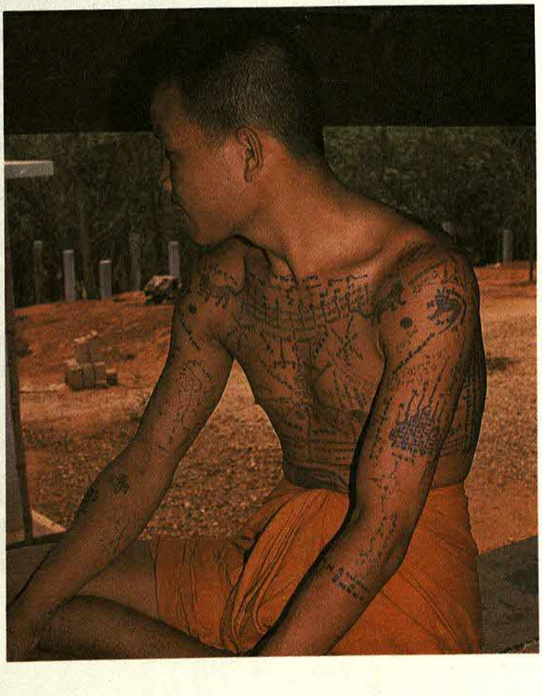
Arthur Tatum was born in Toledo, Ohio, U.S.A. He was blind in one eye from birth and had only slight vision in the other eye. He arrived in New York City in 1932 as an accompanist for a singer. He soon became a favourite soloist in the small nightclubs along Manhattan's West 52nd Street. Tatum led a trio for many years. However, he was one of the rare jazz pianists who needed no support from a rhythm section.

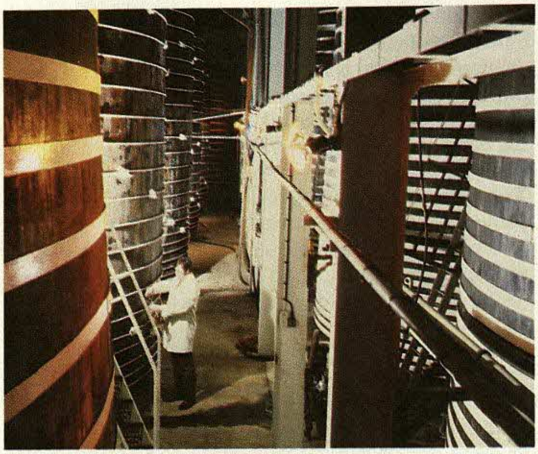
Tatum, Edward Lawrie (1909-1975), an American biochemist, shared the 1958 Nobel Prize for physiology or medicine for discovering that genes regulate specific chemical processes. He and George W. Beadle found that mutations caused by X rays and biochemical processes are passed on to successive generations. Tatum was born in Colorado, U.S.A. See also **Beadle, George W.; Heredity** (The study of the chemistry of genes).

Taunton. See **Somerset.**

Taunton Deane (pop. 93,300) is a local government district in Somerset, England, situated in the Vale of Taunton Deane. Much of the district is devoted to

Tattooing has been practised by almost every culture. People have tattoos for many different reasons. Tattoos may indicate membership of a particular group or religion, *right,* or they may be regarded purely as works of art, *left.*





The cider industry of Taunton produces cider from apples grown in the Vale of Taunton Deane.

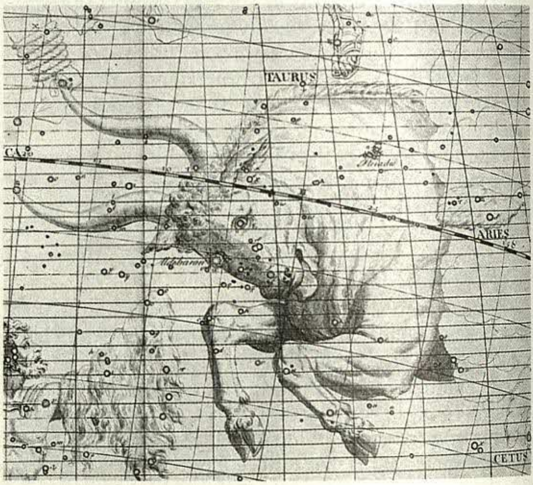
agriculture, and cattle and sheep are widely kept. Orchards produce apples for the local cider industry. Taunton, an old market town, also has clothing, food-processing, and textile industries. See also **Somerset.**

Tauranga (pop. 70,803) is a city in the North Island of New Zealand. Tauranga lies on three peninsulas in the southeastern part of Tauranga Harbour. The city's business area extends to formal gardens beside the harbour. A ferry service runs from Tauranga to Mount Maunganui, a port and pleasure resort on the other side of the harbour. A rail tunnel runs through the Kaimai Ranges to the Waikato district. Europeans first came to the area in about 1830 to buy flax from the Maoris. Gate Pa, near Tauranga, is the site of a famous battle between the Maoris and the Europeans. *The Elms,* a mission house built in 1838, stands near the site.

The city of Tauranga, *above,* lies on the southeastern part of Tauranga Harbour, New Zealand. A ferry service runs from Tauranga to Mount Maunganui, a port and popular resort.

Taurus, *the Bull,* is a *constellation* (group of stars) that forms the second sign of the zodiac. In Greek mythology, Zeus turned himself into a snow-white bull so that he could impress Europa whom he loved. Europa admired the bull and mounted its back for a ride. Zeus revealed his identity and married Europa.

In the sky, Taurus is distinguished by the presence of two open clusters of stars. The V-shaped star cluster, the *Hyades,* marks the bull's face. The Pleiades, a magnificent, more compact star cluster, forms the bull's shoulder. The reddish star, Aldebaran, marks the right eye. Two other stars, Beta and Zeta Tauri, form the tips of the bull's horns. Taurus also includes the Crab Nebula, an expanding mass of gas and dust resulting from a *supernova* (stellar explosion), and T Tauri, a variable star.



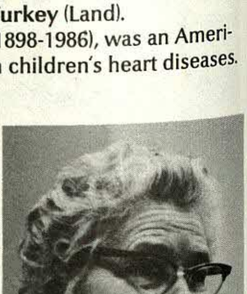
Taurus is a group of stars that forms the second sign of the zodiac. This illustration is from *Atlas Coelestis* by John Flamsteed, first published in 1729.

See also: **Astrology; Supernova; Zodiac.**

Taurus Mountains. See **Turkey** (Land).

Taussig, Helen Brooke (1898-1986), was an American doctor who specialized in children's heart diseases. She discovered the major defect that causes the bluish tinge in the skin of *blue babies* (see **Blue baby**).

From 1930 to 1963, Taussig served as chief of the Cardiac Clinic of the Harriet Lane Home, the children's section of the Johns Hopkins Hospital in Baltimore, Maryland, U.S.A. She found that blue babies have a partial blockage of the pulmonary artery at birth. The heart pumps



Helen Brooke Taussig

blood through this artery to the lungs, where oxygen enters the blood. A lack of oxygen in the blood gives the skin a bluish colour. In 1944, Taussig and a surgeon, Alfred Blalock, developed an operation that enables the blood to bypass the faulty artery.

Taussig was born in Cambridge, Massachusetts, U.S.A. She graduated from the University of California in 1921 and received her M.D. degree from the Johns Hopkins University School of Medicine, Baltimore, in 1927.

Tautog. See **Blackfish.**

Taverner, John (1495?-1545), was one of the most accomplished composers of church music. His works contain some of the best English *polyphonic music* (music in many parts) of the early 1500's. He wrote settings of most parts of the church liturgy and also three secular songs. Taverner was born at Tattershall, in Lincolnshire, England, where he became a choirboy and later choirmaster. In 1528, he was arrested for heresy, but was released because he "was but a musitian." Later, he stopped composing. He also forsook the Roman Catholic Church and became one of its most fanatical opponents.

Tawney, Richard Henry (1880-1962), was a noted British historian and social philosopher. His most famous work, *Religion and the Rise of Capitalism* (1926), related economic growth in the 1500's and 1600's to the spread of Protestantism. According to Tawney, such virtues as hard work and efficiency, stressed by the Protestants, contributed to the success of capitalism. In *The Acquisitive Society* (1920) and *Equality* (1931), Tawney argued for a more just and humane society based on the moderate and democratic socialism of the Fabian Socialists (see **Fabianism**). Tawney was born in Calcutta, India, and attended Oxford University. He was an expert on English history between 1485 and 1715. He was a professor of economic history at London University from 1931 to 1949.

Taxation is a system of raising money to finance government services and activities. Governments at all levels—local, provincial, and national—require people and businesses to pay taxes. Governments use the tax revenues to pay the cost of police and fire protection, health programmes, schools, roads, national defence, and many other public services. *Direct taxes* are *levied* (charged) on the incomes or wealth of individuals or companies. *Indirect taxes* are levied on money spent by individuals or companies..

Taxes are as old as government. The general level of taxes has varied over the years, depending on the role of the government. In modern times, many governments—especially in advanced industrial countries—have rapidly expanded their roles and taken on new responsibilities. As a result, their need for tax revenue has increased.

Over the years, people have frequently protested against tax increases. In these situations, taxpayers have favoured keeping services at current levels or reducing them. Voters have defeated many proposals for tax increases by provincial and local governments.

Kinds of taxes

Governments levy many kinds of taxes. The most important kinds include *property taxes, income taxes,* and *taxes on transactions.*

Property taxes are levied on the value of such property as houses, shops, factories, farms, and business equipment. The property tax first became important in ancient times. Today, it ranks as the chief source of income for many local governments. Property taxes are known as *rates* in some countries. They are called *direct taxes* because they are levied directly on the people expected to pay them. See **Property tax.**

Income taxes are levied on income from such sources as wages and salaries, dividends, interest, rent, and earnings of companies. There are two main types of income taxes—*individual income taxes* and *corporate income taxes.* Individual income taxes, also called *personal income taxes,* are applied to the income of individuals and families. Corporate income taxes are levied on earnings of companies or corporations. Income taxes may also be levied on the earnings of estates and trusts. They generally are considered to be direct taxes. The corporate income tax also may be described as a *shifted tax.* This is because companies shift the cost of the tax to their customers by raising prices.

Most nations in the world levy income taxes. Many people have income tax deducted automatically from their earnings by employers, who then pay it to the tax office.

Capital gains tax is a tax, separate from income tax, levied on profits received from the sale or exchange of real property, shares, or other assets. If losses are made on some sales, they can be subtracted from overall profits to work out the amount liable to capital gains tax. Some countries treat capital gains as ordinary income, and charge income tax on them. See **Capital gains tax.**

Taxes on transactions are levied on sales of goods and services and on privileges. There are three main types of such taxes—*general sales taxes, excise taxes,* and *tariffs.*

General sales taxes apply one rate to the sales of many different items. Australia, Canada, and the United States impose sales taxes. The *value-added tax* is a general sales tax levied in France, Great Britain, and other European countries. It is applied to the increase in value of a product at each stage in its manufacture and distribution. See **Sales tax; Value-added tax.**

Excise taxes are levied on the sales of specific products and on privileges. They include taxes on the sales of such items as petrol, tobacco, and alcoholic beverages. Other excise taxes are the *licence tax,* the *franchise tax,* and the *severance tax.* The licence tax is levied on the right to participate in an activity, such as selling alcholic beverages, using a motor vehicle, getting married, or going hunting or fishing. Franchise tax is a payment for the right to carry on a certain kind of business, such as operating a bus service or a public utility. Severance tax is levied on the processing of natural resources, such as timber, natural gas, or petroleum. See **Excise; Franchise.**

Tariffs are taxes on imported goods. Countries can use tariffs to protect their own industries from foreign competition. Tariffs provide such protection by raising the price of imported goods, thus making these goods more expensive than domestic products. See **Customs; Tariff.**

Stamp duties are taxes levied in Australia, New Zealand, and the United Kingdom on some large transactions. They are mainly used on transfers of property, shares, and bank deposits. See **Stamp duty.**

General sales taxes and taxes on petrol and other products are called *indirect taxes* because they tax a service or privilege instead of a person. Manufacturers and business owners pay these taxes, but they add the cost to the prices they charge their customers. These taxes, like corporation taxes, are a form of shifted taxes.

Other taxes include *estate taxes, inheritance taxes,* and *gift taxes.* An estate tax is applied to the value of property before it has been given to heirs. An inheritance tax is levied on the value of property after it has been given to heirs. A gift tax is applied to the value of property that is given away during a donor's lifetime. The donor pays the tax. Estate and gift duty is levied in New Zealand. Inheritance tax is levied in the United Kingdom and Ireland. Ireland also has a gift tax.

The community charge was a local tax levied on adults in the United Kingdom and collected by the local government. Some types of people, such as those with a mental handicap, were exempt. People with more than one home paid a charge for each. The community charge, introduced in 1989 in Scotland and 1990 in England and Wales, was often called a *poll tax.* It was replaced in 1993 by the *council tax,* a local tax based on property values. See **Poll tax.**

Departure tax is a tax levied in Australia and New Zealand on people departing overseas. It is levied by the federal government in Australia and the national government in New Zealand.

Principles of taxation

A good tax system must satisfy several general principles of taxation. The main principles include *productivity, equity,* and *elasticity.*

Productivity. The chief goal of a tax system is to generate the revenue a government needs to pay its expenses. When a tax system produces such revenue, it satisfies the principle of productivity. If a tax system fails to produce the needed revenue, the government may have to add to its debt by borrowing money in order to cover expenses. Such action is called *deficit financing.*

Equity. Most people agree that a tax system should be *equitable* (fair) to the taxpayers. Economists refer to two kinds of equity—*horizontal* and *vertical.* Horizontal equity means that taxpayers who have the same amounts of income should be taxed at the same rate. Vertical equity implies that wealthier people should pay proportionately more taxes than poorer people. This is sometimes called the principle of *ability to pay.*

A tax that is not equitable is *regressive.* An example of a regressive tax was the community charge in the United Kingdom, which put a proportionately higher burden on people with low incomes. Governments often try to achieve tax equity by making their taxes *progressive.* A progressive tax has a rate that depends on the sum to which it is applied. The rate increases as that sum increases. In most countries, individual income tax is a progressive tax because it applies a higher rate to larger taxable incomes than it does to smaller ones.

Elasticity. A tax system should be *elastic* (flexible) so that it can satisfy the changing financial needs of a government. Under an elastic system, taxes help stabilize the economy. For example, taxes increase during periods of economic growth and thus help limit *inflation* (rapid price increases). Increasing taxes would leave less money for consumers to spend and so send prices up. Similarly, taxes decrease during a decline in economic activity to help prevent a recession. This action would leave consumers more money to spend and so encourage economic growth.

Other principles of taxation. People agree that taxes should be convenient and easy to pay, and that they should be inexpensive for governments to collect. In addition, taxpayers should know in advance when a tax has to be paid, so that they can save enough money to cover the payment.

Some economists believe a tax system should also satisfy the principle of *neutrality.* According to this principle, tax laws should not affect taxpayers' economic decisions, such as how to spend, save, or invest their money. But other economists believe a tax system must defy the principle of neutrality to achieve tax equity or to stabilize economic growth. Still other economists believe a tax system should play an active role in redistributing wealth. They support taxing the wealthy at highly progressive rates and using the collected revenue to finance services for the poor.

History

Tariffs were one of the commonest forms of taxes in the ancient world. But temporary taxes on people or property were sometimes imposed in times of war. The Romans imposed a tax on each citizen, known as a *tributum* and at different times imposed sales taxes, inheritance taxes, and property taxes. Private collectors, known as *tax farmers,* collected taxes for the Romans and received a share of the proceeds.

Tithes were church taxes imposed in early Christian times, based on traditions of the Old Testament. People were required to pay a *tithe* (tenth of their income) to the church. Often they would give a tenth of their crops or animals and *tithe barns* were built in villages to house the grain.

During the Middle Ages in Europe, tariffs and market duties continued to be imposed. Many cities began to levy taxes on land and buildings, as well as a *head* tax on each citizen. Some European cities imposed income tax on the rich, who were required to assess the amount themselves, on oath, before the city council. Since the Middle Ages, luxury goods have often been taxed on the basis that those who could afford to buy them should pay extra to the government for the privilege. Examples of such luxury items include windows, hearths, and hairpowder. Window tax was imposed in Great Britain between 1692 and 1851, on houses with seven or more windows. Hearth tax was levied from 1662 to 1689, although poor people were exempt. Hairpowder tax was imposed in Britain from 1795 to 1869.

Unjust taxation has sometimes led, or contributed to, revolution or civil unrest. Ship tax, originally a charge on sea ports, was extended by King Charles I in 1635, to inland towns in Great Britain. This change was a contributory factor to the English Civil War (1642-1651). The American colonies objected to paying taxes to Great Britain under the Stamp Act of 1765. Protesters adopted the slogan "no taxation without representation" and managed to get the Act repealed in 1766. In France, heavy tax burdens on poor people led to the French Revolution of 1789.

Wars have led to many new taxes or increased taxation. The first general income tax was imposed by Great Britain to finance the Napoleonic Wars in 1799. The United States government imposed income tax during the American Civil War (1861-1865). During World War I (1914-1918), World War II (1939-1945), and the Korean War (1950-1953), the United States levied an excess-profits tax in addition to general income tax in order to finance their war efforts.

Related articles in ***World Book*** include:

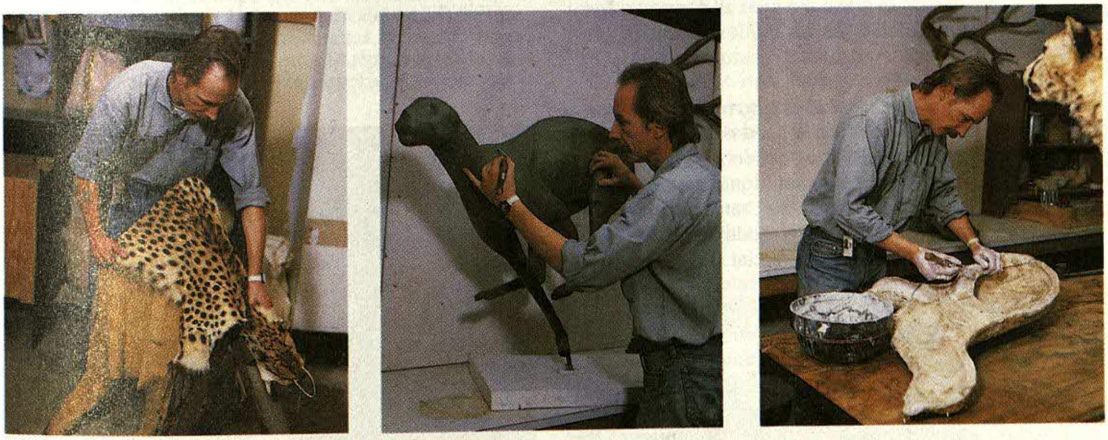
Capital gains tax
Customs
Excise
Franchise
Poll tax
Property tax
Road (How roads are paid for)
Sales tax
Ship money
Stamp Act
Stamp duty
Tariff
Tithe
Value-added tax

Taxco (pop. 86,864) is a historic silvermining town about 110 kilometres southwest of Mexico City. Its official name is Taxco de Alarcón. For location, see **Mexico** (political map). Taxco looks like an old Spanish town. Narrow cobblestone streets climb the steep hills on which it stands. In order to preserve the town's appearance, the Mexican government has made Taxco a national monument. The town's beauty, charm, crafts, and mild climate attract tourists, artists, and writers. Taxco has served as a mining centre since it was founded in 1529. Today, the town serves as the centre of Mexico's silverware industry.

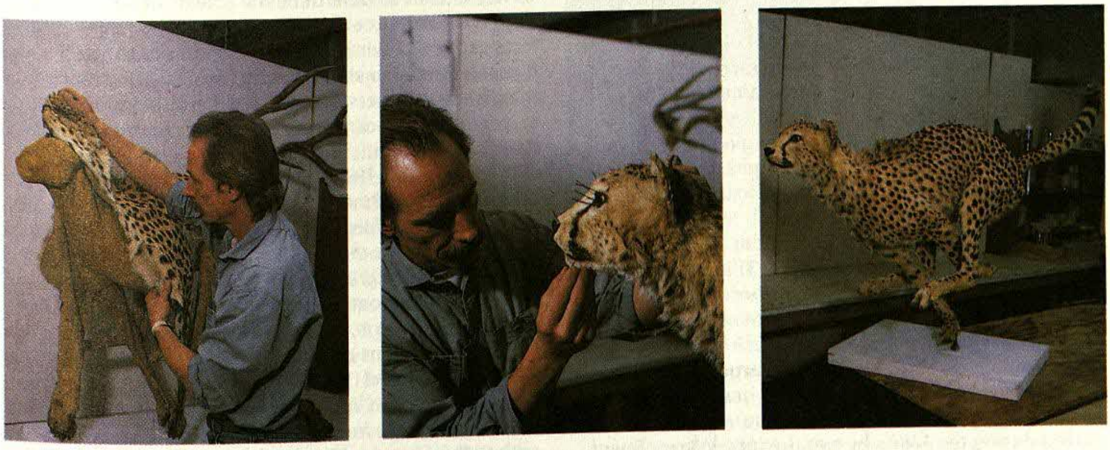
Taxi is a car for hire. It is an important part of the transportation system of a modern town or city. Local laws usually fix the maximum rates for taxis. Almost all taxis have meters, which show the fare for the distance travelled. This instrument was invented by Wilhelm Bruhn in 1891. Some cities have zonal fares. Taxis may charge additional fares when passing from one zone into another.

See also **Jinrikisha; Pedicab.**

Taxidermy is a technique for preserving animals and showing them as they looked when they were alive. The



A taxidermist proceeds through several steps to create a lifelike model of a running cheetah. First, the skin is removed from the animal and tanned, *left.* A clay model of the animal is then sculpted, *centre.* Next, a casting is made from a mould of the sculpture, *right.*



The taxidermist then places the tanned skin on the casting, *left.* Finally, the taxidermist sews, glues, and pins the skin into place, *centre.* After other body features—such as eyes, ears, and a tongue—are added, the model is complete, *right.*

word taxidermy comes from two Greek words meaning *arrangement* and *skin.* Museums of natural history often exhibit a variety of animals in their natural settings.

Process of mounting. The taxidermist first takes accurate measurements of the anatomy of the dead animal. The animal's skin is carefully removed and treated with a preservative, such as arsenical soap. The taxidermist then makes a drawing of the animal's body structure, including the muscles, bones, and depressions. This copy becomes a guide. Next, the taxidermist makes a framework out of wood and metal. The skeleton of the animal also may be used. The taxidermist then adds clay to the framework and sculpts the animal's anatomy. The clay model is used to make a thin, hollow casting of plaster, papier-mâché, burlap, and sometimes mesh wire. This casting must correspond exactly with the figure of the animal. Finally, the taxidermist places the skin on the casting and sews, glues, and pins it together. Skins of large, heavy animals must be tanned before being mounted on the casting.

Taxidermists must add many other body features and use special materials to make the eyes and tongue. Taxidermists may use painted hollow globes instead of glass eyes to give the preserved animal a natural expression. They must also shape the ears.

Some museums use a *freeze-drying* technique to preserve specimens. This method is used mainly for small animals, such as songbirds and squirrels.

Taxidermists must have a knowledge of anatomy, natural history, drawing, sculpture, mechanics, tanning, and dyeing. Many museums have taxidermists on their staffs. Some museums hire commercial studios to mount their specimens. Most taxidermists learn their skills by training under an experienced taxidermist.

Taxonomy. See **Classification, Scientific.**

Tay is the longest river in Scotland, flowing 190 kilometres from its source to the North Sea. It rises as the Cononish on Ben Lui in the western part of Central Region. It flows through Strath Fillan, then continues as the Dochart between mountains into Loch Tay. It becomes the River Tay there and winds through Aberfeldy, Dunkeld, and Perth and into the Firth of Tay.

Tay bridge. See **Dundee** (picture); **Tayside Region.**

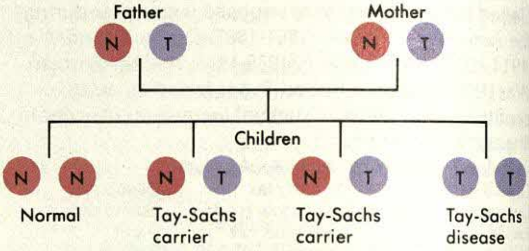
Tay-Sachs disease is a hereditary disorder that occurs chiefly among Jewish children of eastern European ancestry. It causes severe brain damage, enlargement of the head, convulsions, blindness, deafness, lack of energy, and eventually death. Victims develop a reddish spot on the retina of the eye. They begin to have symptoms when they are about 6 months old. There is no treatment for the disease, and most victims live only three or four years.

Tay-Sachs disease occurs in children who have too little of the enzyme *hexosaminidase A.* This enzyme controls the amount of *ganglioside* that accumulates in nerve cells. Ganglioside is a fat produced by normal cell growth. Nerve cells that store too much ganglioside become swollen and eventually die. A large number of damaged or dead nerve cells causes brain damage.

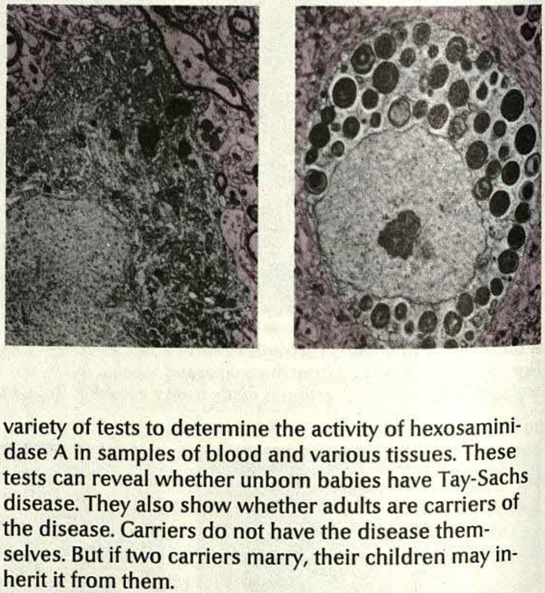
The symptoms of Tay-Sachs disease were first reported during the 1880's by two doctors, Waren Tay of Great Britain and Bernard Sachs of the United States. In 1969, researchers discovered that the lack of hexosaminidase A caused the disease. Today, scientists use a variety of tests to determine the activity of hexosaminidase A in samples of blood and various tissues. These tests can reveal whether unborn babies have Tay-Sachs disease. They also show whether adults are carriers of the disease. Carriers do not have the disease themselves. But if two carriers marry, their children may inherit it from them.

Tay-Sachs disease

Tay-Sachs disease is a hereditary brain disorder that occurs chiefly among Jews of eastern European ancestry. People who inherit the Tay-Sachs gene from both parents have the disorder.



In the chart above, each parent carries one normal gene and one Tay-Sachs gene. Such people are called *carriers.* A child of such parents has one chance in four of inheriting the Tay-Sachs gene from both parents—and thus of having Tay-Sachs disease. People who inherit the Tay-Sachs gene from only one parent do not get the disease, but they may transmit the one abnormal gene to their children. The magnified photographs below show a normal brain cell, *left,* and an abnormal cell from the brain of a Tay-Sachs victim, *right.* The many dark, round bodies in the diseased cell are characteristic of the disorder.



Taylor, Brook (1685-1731), an English mathematician, developed the formula that became the basis of the calculus of *finite differences* (see **Calculus**). This formula, known as *Taylor's theorem,* appeared in his *Methodus Incrementorum Directa et Inversa* (1715-1717). Taylor was born in Edmonton, now part of London. He studied at St. John's College, Cambridge. He was secretary of the Royal Society from 1714 to 1718.

Taylor, Edward (1642?-1729), was the finest poet in colonial American literature. Taylor was born in Leicestershire, England. In 1668, unwilling to sign a loyalty oath to the Church of England, he sailed to New England, in America. In 1671, he became a pastor in Westfield, Massachusetts, where he stayed until his death.

Taylor's best poetry appears in *Preparatory Medita-*

tions, a collection written for his church. In *God's Determination,* he used a debate between good and evil to emphasize God's mercy for people caught in the battle between Jesus Christ and Satan. Taylor achieved his complex thought in a few words. Although his language is complicated, Taylor's use of examples from everyday life makes his poetry understandable.

See also **American literature** (Colonial poetry).

Taylor, Elizabeth (1932-), is an American film actress. She became as famous for her beauty and turbulent personal life as for her film work.

Taylor has appeared in about 50 films. She made her film debut in *There's One Born Every Minute* (1942) and became a child star in *Lassie Come Home* (1943). Taylor won Academy Awards for best actress in *Butterfield 8* (1960) and *Who's Afraid of Virginia Woolf?* (1966). Her other films include *National Velvet* (1944), *A Place in the Sun* (1951), *Raintree County* (1957), *Cat on a Hot Tin Roof* (1958), *Suddenly Last Summer* (1959), and *Reflections in a Golden Eye* (1967).

Elizabeth Rosemond Taylor was born in London to American parents. Taylor has been married eight times, including two marriages to British actor Richard Burton. Taylor has been active in charity work. Since the mid-1980's, she has campaigned to raise funds for AIDS research.

Taylor, G. A. (1872-1928), an Australian pioneer aviator and technician, made what many historians regard as the first flight in Australia. He made this flight in 1909 at Narrabeen, Sydney, in a glider aircraft that he had built. In the early 1900's, he attempted to discover the principles of flight, and in 1908, he began building a series of box kites. The following year, he established the Aerial League, from which Australia's aero club movement developed. In 1910 and 1911, Taylor successfully transmitted radio messages from one moving train to another. George Augustine Taylor was born in Sydney.

Taylor, Sir Geoffrey (1886-1975), an English physicist, devoted a lifetime to science. He was a meteorologist with an expedition in the North Atlantic Ocean in 1913, worked on both meteorology and aeronautics during World War I (1914-1918), and worked on the atomic bomb during World War II (1939-1945). He calculated the slowing-down in the spin of the earth caused by tidal friction. Taylor was born in London.

Taylor, Sir Gordon (1896-1966), helped to make Australian aviation history. He crawled out onto the wing of Sir Charles Kingsford Smith's aircraft *Southern Cross* over the Tasman Sea to feed oil to a failing engine. For this feat of daring, in 1935, he won the Empire Gallantry Medal (changed to a George Cross in 1942). He was navigator with Kingsford Smith in 1934 when they made the first eastbound transpacific flight. One of Australia's greatest pilots, Taylor made the first flight across the Indian Ocean from Australia to Kenya. He, his crew, and two passengers made the flight in 1939 in the *Guba,* a twin-engined Catalina flying boat. Patrick Gordon Taylor was born in Sydney.

Taylor, Jeremy (1613-1667), was an English preacher and religious writer. He is chiefly remembered for his beautifully written books *Holy Living* (1650) and *Holy Dying* (1651). Taylor was chaplain to Charles I and Archbishop William Laud. He was a Royalist supporter during the English Civil War. After Charles II's restoration in 1660, Taylor became bishop of Down and Connor, in Ulster. He was born in Cambridge, England.

Taylor, Squizzy (1888-1927), was a notorious Australian criminal. He was alleged to have been behind many of the serious criminal activities in the city of Melbourne from 1915 to 1927.

Joseph Leslie Theodore Taylor was born in the Melbourne suburb of Brighton. He began work as an apprentice jockey. He was first arrested in 1906 on charges of theft, assault, and using obscene language. Later, he was a pickpocket, a blackmailer, and an organizer of other criminals. By 1913, he was well known. His criminal activities continued, mainly because of a shortage of police and corruption in the police force. Taylor died in 1927, following a duel with another criminal.

Taylor, Zachary (1784-1850), was president of the United States from 1849 to 1850. He died on July 9, 1850, after only 16 months in office. Taylor was a Southern slaveowner, but he did not oppose admitting California and New Mexico to the Union as free (nonslave) states. When the Southern states threatened to secede, Taylor declared he would lead the army to prevent secession. He died at the height of that argument, and compromise was reached after his death.

Taylor was born near Barboursville, Virginia, in the United States. He was a professional soldier. Nicknamed "Old Rough and Ready", he became a U.S. national hero in 1847, during the Mexican War.

Tayra is a large member of the weasel family. It lives in tropical forests from Mexico to Argentina. Most tayras have black or dark brown fur, with a white or yellow patch on the chest. The fur on the head gradually turns brown or grey as the animal grows older. An adult tayra weighs about 5 kilograms and measures about 105 centimetres long, including a tail about 40 centimetres long.

The tayra lives in tropical forests of the Americas.

Tayras wander the forests and are active both day and night. They travel alone or in family groups. Tayras eat birds, small mammals, and fruit. The female tayra gives birth to two to four young in a nest she has built in a tree or on the ground.

Scientific classification. The tayra belongs to the weasel family, Mustelidae. Its scientific name is *Eira barbata.*

Tayside Region lies in eastern Scotland. It is dominated by the city of Dundee, where half of the region's

Dundee University, which got its charter in 1967, lies near the Firth of Tay. A road bridge 2.25 kilometres long crosses the Tay.

people live. Dundee is an industrial town, but most of the region is rural.

Tayside Region was created in 1975, when Scotland's local government was reorganized. Previously, the area had included the counties of Angus and Kinross-shire and the county burgh of Dundee. This region also took over most of the former county of Perthshire. Tayside Region was abolished as a local government area in 1996.

People and government

Recreation. Soccer is by far the most popular sport, and the region has seven clubs that play in the Scottish Football League. Dundee has two League sides—Dundee and Dundee United—whose grounds are virtually side by side.

Winter sports are popular because of the region's easy access to the Cairngorm and Grampian mountains. The region has some championship golf courses, such as Carnoustie and Gleneagles.

Local government. The region had three districts: *Angus,* which included Arbroath, Forfar, and Montrose; *Dundee;* and *Perth and Kinross.* The region's police force is based at Dundee. In April, 1996, Tayside Region was replaced by three new unitary authorities.

Facts in brief about Tayside Region

Largest towns: Dundee, Perth, Arbroath, Forfar, Montrose.
Area: 7,500 km².
Population: *1991 census*—385,271.
Chief products: *Agriculture*—beef and dairy cattle. *Manufacturing*—engineering goods, printing, processed foods, textiles.

Economy

Manufacturing. Dundee is Scotland's second most important manufacturing city. Dundee's most important industries are textiles and publishing. The jute industry dominated the town during the years between World War I (1914-1918) and World War II (1939-1945). In recent years, the industry has broadened its scope. It now makes many products in addition to traditional jute sacking. It also uses fibres other than jute, including such synthetic fibres as polypropylene.

The Dundee printing and publishing industry centres on the firm of D. C. Thomson. This firm produces, in addition to the local newspapers, a wide range of popular national magazines, such as *Scots Magazine, Annabel,* and *Jackie.* Some of Dundee's newer industries are in industrial estates. They include engineering and the production of electronics goods, textiles, and tyres. During the early 1970's, Dundee became an important supply centre for the North Sea oil industry.

Smaller towns in Tayside Region all have some industry. Small engineering factories are widespread in the region. Other industries include whisky distilling at Aberfeldy and Pitlochry and whisky bottling at Perth, engineering and textiles at Arbroath, and industries related to oil and pharmaceuticals at Montrose.

Agriculture plays an important part in the region's economy, particularly in Strathmore. Many farms have amalgamated during recent decades, and the region has a number of farms larger than 800 hectares. Many farmers practise mixed farming. In Strathmore, the emphasis is on grassland or forestry. Strathmore is also a potato-growing district. Tayside is the centre of a cattle-raising area. It has about 400,000 beef and dairy cattle.

Loch Tay, in the western part of Tayside Region, is one of many attractions in the area for walkers and anglers.

Raspberries and other soft fruit are especially important in Perth and Angus. The Carse of Gowrie, between Perth and Dundee, is traditionally a raspberry-growing area. Some soft fruit goes into making jams and preserves. Farmers also export much soft fruit to other parts of Europe. New crops include vegetables and bulbs.

Tourism is important in the western part of the region. With recent development of winter sports, tourism has become a year-round industry. Facilities are also good for fishing, hill-climbing, and water-skiing.

Transportation and communication. Roads are improving to meet the needs of tourism and of the North Sea oil industry. The M90 leads south out of the region towards Edinburgh. The A9 from Stirling runs through Perth, then northwest towards Inverness.

A main railway line runs from Glasgow through Perth and Dundee to Aberdeen. Another line from Dundee leads to Edinburgh. From Perth, a line leads northward to Inverness. Dundee has docks that can accommodate fairly large ships. Smaller vessels can sail up the Tay to Perth. Dundee airport has regular services to Manchester, the Shetlands (via Aberdeen), and Denmark.

Dundee has its own daily morning and evening newspapers. Radio Tay is an independent local station serving Tayside Region and part of Fife Region.

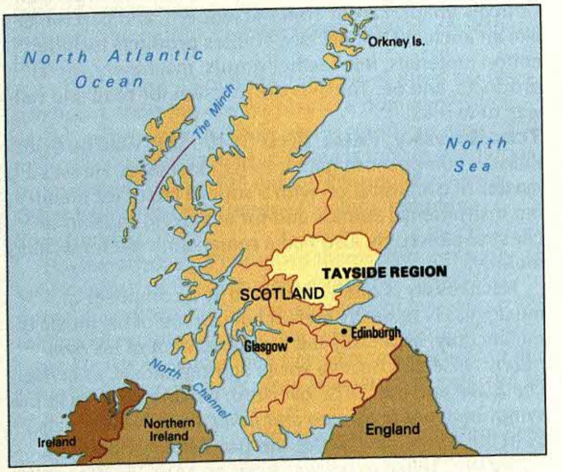
Land

Location and size. Tayside Region is bounded by Grampian Region and Highland Region to the north, by the North Sea to the east, by Fife Region and the Firth of Tay to the south, and by Strathclyde Region and Central Region to the west. Its maximum dimension from north to south is about 90 kilometres and from east to west about 135 kilometres.

Land features. A major geological feature called the *Highland Boundary Fault* runs across Tayside Region. To the north and west of the fault line is a mountainous area with peaks reaching up to about 1,200 metres. This area includes the Grampians. To the south and east of the fault line is lowland, with fertile soils. The lowland is broken by the Sidlaw and Ochil hills, which lie between a broad valley called Strathmore and the coast. These hills rise to a maximum height of 716 metres.

Rivers and lochs. Most of the region's rivers are tributaries of the River Tay, which is the longest river in Scotland. The upper parts of the river are important for hydroelectric power generation. A dam at Pitlochry is a popular tourist attraction. It has a *salmon ladder* by which fish can go above the dam. The region has some picturesque *lochs* (lakes) among the mountains.

Climate. The region has cool but sunny summers and cold winters. Annual rainfall is highest in the mountains in the west, where it averages about 2,800 millimetres. Rainfall on the coast averages about 760 millimetres. Snowfalls are heavy in the mountains in winter, but even in midwinter, snow seldom lies long on the coast. The average midwinter temperature is 3° C, and the average midsummer temperature is 14° C.



Tayside Region lies in eastern Scotland. The Firth of Tay forms part of its southern border.

History

The region was probably important during the Iron Age. A large number of carved stones, found in all parts of the region, indicate that it was a major trading and cultural centre for an early people called the Picts.

At Scone, near Perth, Scottish kings were crowned on the Stone of Destiny until the reign of James IV. Perth was Scotland's capital for a time. Both Perth and Dundee were involved in the Scottish wars of independence.

Perth and Dundee also became involved in warfare at the time of the English Civil War. The Scots sided with Parliament against Charles I, but rebelled after he was executed. Cromwell's troops severely damaged both Perth and Dundee in 1651. Dundee suffered an economic disaster, and took more than a hundred years to recover.

In 1689, John Graham of Claverhouse, called "Bonnie Dundee," defeated the army of William III at Killiecrankie, near Pitlochry. Perth and Dundee were both active during the Jacobite risings in 1715 and 1745. But during the 1745 Jacobite rising, the people of Dundee feared another economic disaster and turned against the rising.

Famous people associated with Tayside Region include Mary Slessor, a missionary, who lived in Dundee. Sir Robert Watson-Watt, inventor of radar, was born in Brechin. Fanny Wright, a pioneer of women's rights, was born in Dundee.

Related articles in ***World Book*** include:

Barrie, Sir James M.
Dundee
Jacobite risings
Kings and queens of Britain and Ireland
Perth and Kinross
Pitlochry
Scone, Stone of
Scotland, History of
Slessor, Mary
Watson-Watt, Sir Robert A.

TB. See **Tuberculosis.**

Tbilisi (pop. 1,140,000) is the capital of Georgia. Georgia was a republic of the Soviet Union until 1991, when Georgia declared its independence. Later that year, the Soviet Union collapsed.

The name *Tbilisi* means *warm springs* in the Georgian language. The city used to be called *Tiflis,* its name in Russian. It lies on the Kura River in eastern Georgia (see **Georgia** [map]). Part of Tbilisi is modern, and part looks like an ancient Oriental city. Tbilisi's products include cotton materials, felt, leather goods, machinery, metal products, and oil. Tbilisi is the junction for road and railway networks.

Tchaikovsky, Peter Ilich (1840-1893), was the first Russian composer to gain international fame. He was a master of orchestration with a superb talent for blending instrumental sounds and for achieving rousing orchestral effects. He also had a remarkable gift for writing melody.

Tchaikovsky is often described as a composer of music that is basically melancholy. Some of his music is melancholy, especially the last movement of his *Symphony No. 6.* But he also wrote spirited music, as in *Marche Slave* and the "1812" overture; lyrical music, as in the symphonic poem *Romeo and Juliet;* lively ballet music, as in the *Nutcracker Suite;* and powerful symphonies.

His life. Tchaikovsky was born on May 7, 1840, in Votkinsk, Russia. He entered a law school in St. Petersburg in 1850. From 1862 to 1866, he studied music at the St. Petersburg Conservatory under Anton Rubinstein, a pianist and composer. Tchaikovsky was the first Russian composer to receive systematic training in music fundamentals.

Peter Tchaikovsky

From 1866 to 1877, Tchaikovsky taught at the Moscow Conservatory of Music. He began composing seriously in about 1866. At this time, his early emotional sensitivity developed into long periods of depression. Curiously, he wrote some of his most cheerful music during these periods. He was married in 1877, but he and his wife separated within a few weeks. This experience brought Tchaikovsky close to a nervous breakdown.

In 1876, Nadezhda von Meck, a wealthy widow, commissioned some works from Tchaikovsky. She admired his music and agreed to support him so he could compose at leisure. She insisted that they never meet, but they exchanged letters for years. Assured of an income, Tchaikovsky left the Moscow Conservatory and concentrated on composing. He travelled widely, and in 1891 took part in the opening of Carnegie Hall in New York City. He died on Nov. 6, 1893.

His works. Tchaikovsky's six symphonies stand out as landmarks in his artistic development. His first three are seldom performed today. His fourth, written in 1877, is his first masterpiece in the symphonic form. Tchaikovsky's *Symphony No. 5* (1888) is his finest from the standpoint of formal construction. *Symphony No. 6* (1893) is called the "Pathétique" ("Pathetic"). It departed from the traditional symphonic form by expressing a deeply emotional feeling of tragedy in the final movement. Tchaikovsky's other orchestral works include *Italian Capriccio* (1880), *Nutcracker Suite,* and four other suites.

Tchaikovsky's *Concerto for Piano and Orchestra No. 1 in B flat minor* (1874-1875) and his *Violin Concerto in D major* (1878) are classics of their types. Tchaikovsky also wrote an important work for violoncello—*Variations on a Rococo Theme for Violoncello and Orchestra* (1876). He composed vocal pieces and works for solo piano.

Tchaikovsky's three ballets have become classics. They are *Swan Lake* (1875-1876), *Sleeping Beauty* (1888-1889), and *The Nutcracker* (1892). Tchaikovsky wrote 11 operas, but only *Eugene Onégin* (1877-1878) and *Queen of Spades* (1890) are well known outside Russia. Both have *librettos* (words) based on works by the Russian poet Alexander Pushkin. *Queen of Spades* is written on a larger scale than *Eugene Onégin.* It is a powerful psychological music drama dominated by the idea that fate rules human beings.

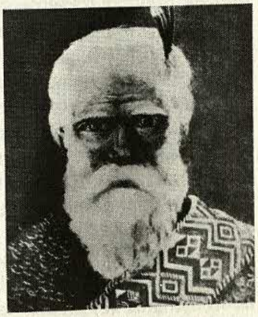
Tchaikovsky has often been described as a "Westerner" among Russian composers. He was the first Russian composer to write polished music in the Western manner and the first to win widespread popularity outside Russia. Some critics tend to see the melancholy strain in Tchaikovsky's music as almost the only trace of his Russian origin. But Tchaikovsky always claimed to be fully Russian in his feelings, and his works contain quotations from Russian folk melodies. He cited Mozart, a Westerner, and Mikhail Glinka, a Russian, as the composers who influenced him the most. Much of Tchaikovsky's work represents a blend of the spirits of these two widely different composers.

Te Kanawa, Dame Kiri (1944-), a New Zealand opera singer, is one of the most praised sopranos in the world. She has sung the major roles in operas of such composers as Wolfgang Amadeus Mozart, Giacomo Puccini, Giuseppe Verdi, Georges Bizet, and Richard Strauss. Her voice is rich and lyric, and impresses with its freshness and warmth.

Kiri Te Kanawa

Te Kanawa was born in Gisborne, New Zealand. Her first major operatic success came in 1971 in the role of Countess Almaviva in Mozart's *The Marriage of Figaro* at Covent Garden in London. In 1974, she made her debut with the Metropolitan Opera in New York City. This appearance took place with about three hours' notice, when she substituted for an ailing performer as Desdemona in Verdi's *Otello.* Her performance helped make her an international star. In 1982, she was made a Dame Commander of the Order of the British Empire.

Te Kooti (1831-1893), a warrior chief, was one of the greatest of the Maori leaders during the New Zealand Wars. In 1865, police and soldiers pursuing members of the rebel Hau Hau movement arrested him because they suspected that he was a Hau Hau spy. Without even giving him a trial, the government exiled him to the Chatham Islands, an island group about 725 kilometres east of New Zealand.



Te Kooti

In exile with many other Hau Hau rebels, Te Kooti plotted revenge for what he considered his unjust imprisonment. He also became the prophet of a Maori religious movement known as *Ringatu.* In 1868, he and a number of fellow prisoners overpowered their guards and captured the schooner *Rifleman,* which had carried supplies to the Chatham Islands. Te Kooti and the other rebels then forced the ship's crew to sail to the North Island of New Zealand, where they hoped to be allowed to return to their homes in peace. But after Te Kooti landed in the Poverty Bay area, government soldiers tried to capture him. He and his followers then raided settlements in the Bay of Plenty district, killing 32 Europeans and about 40 Maoris in one raid alone.

The government offered a large reward for Te Kooti's capture. But he escaped to the safety of the King Country, an area held largely by the Maoris. Te Kooti was later granted a pardon.

Te Rauparaha (1768-1849), a Maori chief, was one of the greatest and most ruthless of all the Maori warriors known to Europeans. Both Maori and *pakehas* (white people) feared and admired him even more than the other great warrior chiefs of his time, such as Hongi Hika, Mananui Te Heu Heu, and Te Wherowhero. For 22 years, Te Rauparaha, who was chief of the Ngati-Toa tribe, led his followers in ferocious attacks on other tribes in the southern part of the North Island and in the northern part of the South Island.

Te Rauparaha

In 1821, Maori from the Waikato trespassed on the fishing grounds of the Ngati-Toa tribe, near Kawhia, on the northwestern coast of the North Island. In revenge, Te Rauparaha formed a war party, killed two Waikato chiefs, and then ate them. Incensed at this incident, Maori from the Waikato tribes prepared a major attack on the Ngati-Toa tribe. But the Ngati-Toa escaped the attack, and Te Rauparaha led them in a great *heke* (migration) to Kapiti Island, near the southwestern coast of the North Island. In 1823, he and his followers attacked this island fortress and seized it from the Ngati-Apa tribe.

From Kapiti, Te Rauparaha raided other tribes. The most ferocious of his raids was on a village of the Ngai-Tahu, a South Island tribe, at Akaroa, in 1830. He persuaded a whaling captain to carry him and his warriors to Akaroa. After killing the villagers, the Ngati-Toa warriors returned to Kapiti on the whaling ship. They carried baskets of human flesh with them.

Te Rauparaha terrorized and killed Europeans after immigrants from the United Kingdom settled in the Wellington and Nelson areas in the 1840's. In 1846, British soldiers captured him at Porirua and placed him under open arrest for two years.

Tea is a beverage prepared by pouring boiling water over dry processed tea leaves. It ranks as the most popular refreshing drink in more countries than any other beverage.

In 1990, about 2.5 billion kilograms of dried tea were produced. India has always played a dominant role in world tea production. Today, India produces about 720 million kilograms each year. China is the second largest producer with about 525 million kilograms annually. Other tea-producing countries include Indonesia, Kenya, and Sri Lanka.

The tea-producing countries themselves consume over one-half of the global tea crop. The United Kingdom (UK) imports the greatest amount of tea—about 180 million kilograms annually. On average, about 3.2 kilograms of tea are consumed per person each year in the UK where a cup of tea is often affectionately referred to as a "cuppa."

Tea is also a popular drink in Australia and New Zealand. On average, each Australian drinks about 1.4 kilograms of tea each year. The people of New Zealand drink a similar amount of tea.

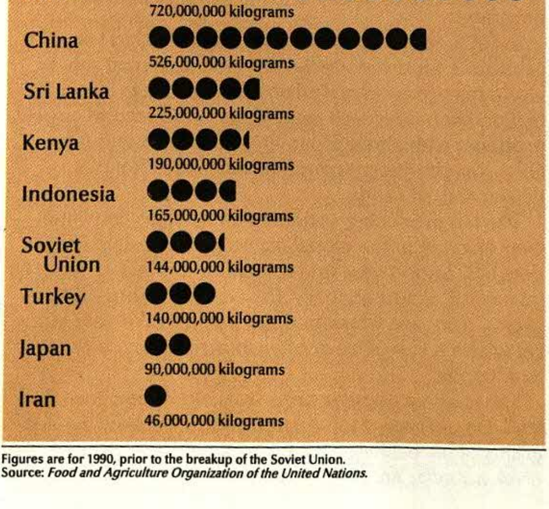
Tea pluckers near Kandy, Sri Lanka, pick leaves from mature tea plants, *left.* The tea plants produce shoots called *flushes,* which consist of several leaves and a bud, *above.* After being picked, the flushes are processed into tea in a nearby factory.

From leaf to cup

The tea plant grows in tropical and subtropical climates. The plant, an evergreen, grows quickly at low altitudes where the air is warm. The finest tea comes from elevations of 900 to 2,100 metres. The plant grows more slowly in cool air, adding to its flavour.

Tea plants have small, white, sweet-smelling flowers. Each flower produces three seeds that look like hazelnuts. On a tea estate or in a tea garden where tea plants are grown commercially, workers plant the seeds in a nursery bed. Another method of cultivating tea involves planting cuttings of tea plants in the bed. The grower will select plants with desirable qualities, such as high yield or special flavour. About a year later, when the plants have reached a height of approximately 20 centimetres, they are transplanted to the field. About 7,500 tea plants grow on 1 hectare of land.

Leading tea-growing countries



Figures are for 1990, prior to the breakup of the Soviet Union.
Source: *Food and Agriculture Organization of the United Nations.*

Wild tea plants grow as tall as about 9 metres. But a commercial tea plant is pruned to keep it between about 90 and 120 centimetres high. The plant matures in three to five years and produces a *flush* (growth of new shoots). Each shoot consists of several leaves and a bud. At lower altitudes, tea plants may grow a flush every week. At higher altitudes, a plant needs as long as two weeks to grow a flush. Tea plants do not produce flushes in cold weather.

Workers called *tea pluckers* pick the flushes off the bush by hand. A plucker can harvest about 18 kilograms of tea leaves a day, enough to make about 4.5 kilograms of manufactured tea.

Mechanical pluckers are common in countries with flat land. These devices are tractorlike machines that can harvest as much tea leaf as up to 100 manual pluckers. However, tea of higher quality is generally produced from leaves that have been hand-plucked.

Processing tea. There are three main kinds of tea: (1) black, (2) green, and (3) oolong. They differ in the method used to process the leaves. The processing takes place in a factory on or near the tea estate. All tea-producing countries manufacture black tea. Most of the green and oolong tea comes from China, Japan, and Taiwan.

Black tea. To make black tea, workers first spread the leaves on shelves called *withering racks.* Air is blown over the leaves to remove excess moisture, leaving them soft and flexible. Next, the leaves are crushed between the rollers of a machine to release their flavourful juices. Then, in a *fermenting room,* the tea leaves change chemically under controlled humidity and temperature until they turn coppery in colour. Finally, the leaves are dried in ovens and become brownish-black.

Green tea is made by steaming the leaves in large vats. The steaming prevents the leaves from changing colour. The leaves are then crushed in a machine and dried in ovens.

Oolong tea is made by partially fermenting the leaves. This gives tea leaves a greenish-brown colour.

Grades of tea differ only according to the size of the leaves. The size of a tea leaf has nothing to do with the quality of the tea.

To sort the processed tea leaves by grade, they are passed across screens with different size holes. The largest leaves, selected for packaging as loose tea, are classified—in order of size—as *orange pekoe, pekoe,* and *pekoe souchong.* The smaller or broken leaves, generally used in tea bags, are classified as *broken orange pekoe, broken orange pekoe fannings,* and *fannings.*

Instant tea is made by brewing tea on a large scale and then removing the water by a drying process. When the process is completed, only a powder remains. The powdered tea combines easily with moisture, and so it must be packed under controlled humidity and temperature. People make instant tea at home by simply adding water to the powder.

Teas grown in different countries, or even in different parts of the same country, vary in taste, flavour, and quality. To obtain the best teas, each tea company employs *tea tasters* who select only certain teas for purchase. These teas, after being blended by the company, have a flavour for which the firm is known. The company then sells its blend of tea under its own brand name.

Brewing tea. Tea is brewed by pouring boiling water over one teaspoon of loose tea, or one tea bag, per cup. To obtain the best flavour, the teapot should be rinsed beforehand with hot water, so as to warm it, and the tea should be left to *steep* (soak) for three to five minutes before being served. People who prefer weak tea can add hot water.

Iced tea, a popular beverage in summer, is prepared by first brewing a strong hot tea. For each two glasses, three teaspoons of tea or three tea bags should be used. After steeping for five minutes, the tea is cooled at room temperature and served over ice cubes, with lemon juice and sugar if desired.

In China and Japan, tea making and tea drinking gave rise to the *tea ceremony,* a ritual that was originally religious, but later was carried to extraordinary lengths by wealthy nobles, who added entertainment and the giving of expensive gifts. The tea-making equipment and cups were often of exquisite design.

History

According to legend, the use of tea was discovered by Emperor Shennong of China in about 2737 B.C. The earliest known mention of tea appeared in Chinese literature of about A.D. 350. The custom of tea drinking spread to Japan around 600 A. D. The first shipment of tea to Europe was made in 1610 by Dutch traders who imported it from China and Japan.

In 1657, tea was sold for the first time in coffee houses in England. It went on to become the national drink of Britain, now the United Kingdom. In 1767, Britain placed a tax on the tea being used by the American colonists. Colonial resistance to the tax brought about the Boston Tea Party in 1773 and contributed to the American independence movement (see **Boston Tea Party**). Tea bags were invented by Thomas Sullivan, a New York City coffee and tea merchant, in 1904.

Scientific classification. The tea plant is a member of the tea family, Theaceae. It is *Camellia sinensis.*

See also **Caffeine; Japan** (picture: Japanese agriculture); **Kenya** (picture: Kenya's highland); **Labrador tea; Maté.**

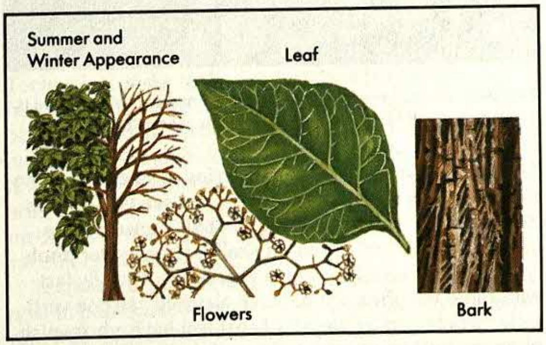
Teach, Edward. See **Blackbeard.**

Teacher. See **Education.**

Teagarden, Jack (1905-1964), was an American trombone player and blues singer. His intense, warm, blues-rooted trombone style was widely imitated. Teagarden was also the first successful nonblack blues singer. His most famous records are "I've Got a Right to Sing the Blues" and "Basin Street Blues." They illustrate his rich, deeply moving vocal style.

Teagarden was born in Vernon, Texas, U.S.A. He was partly American Indian in ancestry. His full name was Weldon John Teagarden. Mainly a self-taught musician, Teagarden went to New York City in 1927 and toured with Ben Pollack's band from 1928 to 1933. He later performed with Paul Whiteman's band and recorded with Benny Goodman. He led his own band from 1939 to 1947, and worked for four years with Louis Armstrong. He led small groups after 1951.

Teak is a forest tree native to the tropical forests of Southeast Asia. Its wood is highly valued for shipbuilding and for making furniture. Teak wood is strong



The teak tree grows in forests of southeastern Asia.

Teak is used in making ships, furniture, and other products. A panel of teak, *left,* has beautiful grain patterns. A statue of an elephant, *right,* was carved from teak.

and durable and resists water. It takes a high polish and contains an oil that helps it resist insects and decay. The teak tree sometimes grows to a height of 45 metres. The leaves often grow 60 centimetres long and 45 centimetres wide. They yield a purple dye and are also used for thatch and for wrapping material.

Teakwood is produced commercially throughout most of the teak tree's natural range—in India, Burma, and Indonesia. Because of its commercial value, the tree has been widely planted throughout the world. Today, teak trees are also commercially harvested in tropical Africa and Latin America.

Scientific classification. The teak tree is in the family Verbenaceae. Its scientific name is *Tectona grandis.*

The Baikal teal lives in northeast Asia. The head of the male is a rich pattern of black, brown, buff, white, and green.

Teal is the name of about 15 species of small, dabbling ducks. Teal feed on aquatic plants and seeds by sifting them with a nibbling action of the bill. They may also upend to feed. Teal breed on shallow freshwater pools and lakes bordered by dense vegetation. They fly fast with rapid wingbeats and, when alarmed can rise vertically from the water surface. Most teal have a brownish plumage broken up with light- and dark-coloured markings. The males of some species have bright-coloured heads. The *Baikal teal* of northeastern Asia has one of the most elaborate and colourful head patterns which consists of black, brown, buff, white, and green, in stripes and patches.

The *common teal,* known in North America as the green-winged teal, is widely distributed across the Northern Hemisphere. It is about 35 centimetres long. The male is distinguished by its chestnut head and green eye patches. The female alone incubates the eggs and feeds the young.

One of the rarest species is the *brown teal* of New Zealand. It has a dark brown head with white eye rings. This bird is very secretive and mainly nocturnal. Of the three subspecies, only one can fly. There are thought to be about 1,500 of these birds remaining in the wild.

Scientific classification. Teal belong to the family Anatidae, genus *Anas.* The Baikal teal is *A. formosa;* the common teal is *A. crecca;* and the brown teal is *A. auklandica.*

Teapot Dome was one of the most notorious government scandals in United States history. It occurred in the Administration of President Warren G. Harding and contributed to his low standing among U.S. Presidents.

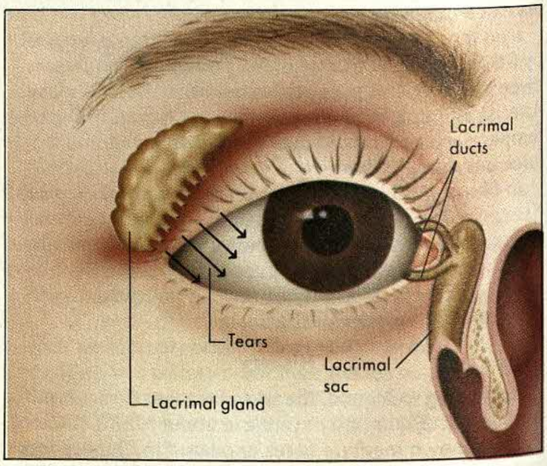
Committees of the U.S. Senate and a special commission investigated the scandal from 1922 to 1928. The investigators found that Secretary of the Interior Albert B. Fall had persuaded Harding to transfer control of three naval oil reserves from the Department of the Navy to the Department of the Interior in 1921. Fall leased the reserves, at Elk Hills, California, and Teapot Dome, Wyoming, mostly without competitive bidding to the private oil companies of Edward L. Doheny and Harry F. Sinclair in 1922. For helping to arrange the Elk Hills transfer, Fall received a "loan" of 100,000 U.S. dollars from Doheny. For Teapot Dome, Fall received over 300,000 U.S. dollars in cash, bonds, and valuable livestock from Sinclair. Fall resigned in 1923 and joined Sinclair's oil business.

In 1927, the government successfully sued to cancel the leases. In 1929, Fall was convicted of accepting a bribe, fined 100,000 U.S. dollars, and sentenced to a year in prison. He was the first Cabinet member ever to go to jail for crimes committed while in office.

Tear gas. See **Chemical-biological-radiological warfare; Mace** (gas).

Tears are the secretion of the lacrimal glands. The tears continually bathe the *cornea,* the tough outer layer of the eyeball. They help clear it of foreign particles, such as dust and hairs, and keep it from drying out, which would result in blindness.

Two lacrimal glands, one over each eye, lie behind the eyelid. They pour out their fluid through several small ducts in the underside of the lid. Each time the eyelid blinks, it sucks a little fluid from the glands. When a person feels some emotion such as grief or anger very



Tears are produced by the *lacrimal glands,* one of which lies above each eyeball. The tears wash across the eye and empty into the *lacrimal ducts,* which lead to the *lacrimal sac.* From there, they drain through a passage into the nose.

strongly, the muscles around the lacrimal glands may tighten up and squeeze out the tear fluid. The same thing happens if a person laughs very heartily.

After the tears pass across the eyeball, they flow out through two lacrimal ducts that open at the inner corner of each eye. They lead to a lacrimal sac and then to the nasal duct. This duct runs the length of the nose and finally opens into it. Tears flowing through this opening make the nose run when a person cries.

Mostly a salt solution, lacrimal fluid also contains substances that fight bacteria and proteins that help make the eye immune to infection.

Teasel is the name of a group of plants that have one commercially valuable species. This species is the *fuller's teasel, clothier's teasel,* or *clothier's brush,* from southern Europe. It is used to raise the nap on cloth.

The plant is a thistlelike herb with long, stemless leaves, prickly stems, and stiff bracts surrounding the flower heads. It can grow up to 2 metres tall. The parts used are the dry flower heads, whose fresh flowers are tubular, and which are pale lilac or white in colour. The heads are cut in two and attached to a cylinder which revolves against the cloth. The best heads are used for raising the nap on men's garments. The largest are used on blankets. Small heads are used for fine woollens. No mechanical device can replace these heads satisfactorily.

Teasel flower head

Scientific classification. Teasels belong to the teasel family, Dipsacaceae. They make up the genus *Dipsacus.* Fuller's teasel is classified as *D. fullonum.*

Teatree is any one of about 50 kinds of woody shrubs or small trees that grow in Australia and New Zealand. One was used by the British explorer James Cook as a "tea" plant. The teatree's flowers are open and roselike. They are commonly white or pink. Gardeners cultivate teatrees and some kinds of the plants have been extensively *hybridized* (interbred with other kinds).

Scientific classification. Teatrees belong to the family Myrtaceae. They form the genus *Leptospermum.*

Tebaldi, Renata (1922-), an Italian singer, became one of the great operatic sopranos of her time. Her voice was noted for its evenness and velvety quality. Tebaldi performed almost exclusively in Italian operas. Her early lyric roles included Desdemona in *Otello* and Mimi in *La Bohème.* She progressed to more dramatic roles, including the title roles in *Aida* and *Tosca.* Tebaldi was born in Pesaro, Italy. She made her debut in Rovigo, Italy, in 1944 as Elena in *Mefistofele.* From 1949 until 1954, she sang with the La Scala company, Milan. She also sang at the Teatro San Carlo, Naples; at Covent Garden, London; and at the Metropolitan Opera, New York City.

Renata Tebaldi

Tebbit, Norman (1931-), a British Conservative Party politician, was chairman of his party from 1985 to 1987. He served as secretary of state for trade and industry from 1983 to 1985, and as chancellor of the Duchy of Lancaster from 1985 to 1987.

Norman Beresford Tebbit was educated at Edmonton County Grammar School, in north London. He worked briefly in publishing and advertising, and then became an airline pilot. Tebbit became a member of Parliament in 1970. After holding some minor government posts, he became secretary of state for employment in 1981. He was created a life peer in 1992.

Technetium is a chemical element with symbol, Tc. It was the first artificially created element. Its atomic number is 43. The most stable available isotope has a mass number of 98.906. In 1937, Carlo Perrier and Emilio Segrè isolated technetium in Italy. They produced it from a sample of molybdenum that had been bombarded with deuterons in the cyclotron of E. O. Lawrence in California, U.S.A. (see **Cyclotron**). Perrier and Segrè proved that the bombardment left one proton in the molybdenum and formed technetium. Scientists first called the element *masurium* and thought that it occurred in nature. However, only small quantities are produced naturally, so the name was changed to technetium, which means *artificial.* Technetium is now obtained in large quantities as a by-product from atomic fission. Its properties resemble those of manganese and rhenium. Its melting point is 2200° C, and its density is 11.5 grams per cubic centimetre at 25° C. One form of technetium is a good radiation source.

Technical drawing, also called *mechanical drawing,* refers chiefly to a drawing produced with instruments. However, some technical drawings are made freehand. Technicians make technical drawings to show exactly how to construct or use machines, buildings, or other objects. No ship, aeroplane, car, bridge, dam, engine, or any of the tools of industry could be made without such drawings. The father of modern drawing was the Italian artist Leonardo da Vinci. He practised and taught a method of drawing that recorded ideas about mechanical objects and systems.

Technical drawings do not show objects as they appear in photographs because photographs do not indicate true dimensions. Instead, a technical drawing shows as many views of an object as may be necessary to define its exact shape and size. The most common method is called *orthographic,* or right-angle, projection. This presents views of an object as seen from the front, side, and above. Another method, called *isometric* drawing, gives a distorted view of the front, top, and one side of an object.

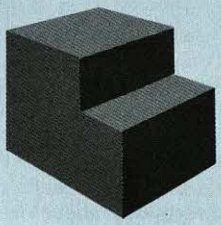
Materials needed. A simple set of instruments to make technical drawings consists of a drawing board, a scale, a T square, triangles, a compass, draughting tape, drawing pencils, an eraser, and draughting paper. Curves, inking pens, dividers, protractors, a ruler, and blueprinting or other copying machines may also be used. A device called a *draughting machine* is a combination of several drawing tools. Much of the technical

Technical drawing requires skill and attention to detail. A technician uses a variety of instruments to create a drawing that indicates the exact shape and size of an object.

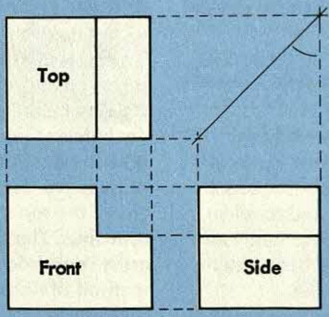
A draughting machine, such as the one shown above, combines several drawing tools—a protractor, scale, T square, and triangle. The device helps a technician work quickly and efficiently.

Mechanical drawing

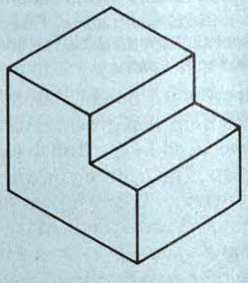
Drafters prepare mechanical drawings to provide technical information. Unlike a photograph or a perspective drawing, a mechanical drawing presents various views of an object to define its dimensions. Common drafting methods include *orthographic projection* and *isometric drawing.*



Any object may have many structural details that are not clearly visible.



An orthographic projection gives the exact shape and size of the object from three views.



An isometric drawing shows one distorted view of the top, front, and one side of the object.

drawing that is done today is accomplished by using computer-aided design and draughting.

See also **Blueprint; Pantograph; Protractor.**

Technicolor is a patented process for making films in colour. It involves producing three separate black-and-white negatives of a scene. Each negative is exposed to one of the *primary colours*—red, blue, or green—from the scene. The negatives are developed into positive images. The positives are dyed to reproduce the red, blue, and green areas recorded on the negatives. Next, the dyed positive images are transferred onto blank film to make the final print. The transferred colours blend to produce all the original colours of the filmed scene.

Herbert T. Kalmus, an American chemical engineer, developed Technicolor as a two-colour process in the early 1900's. The first full-length film made with the process, *The Gulf Between,* appeared in 1917. The three-colour process was introduced in 1932. Many Technicolor films were made in the 1930's and 1940's. Technicolor has largely been replaced by cheaper processes.

An automated steel mill produces huge steel bars at the touch of a button. The computer-controlled machines that roll the glowing bars are products of modern technology. Other machines and methods will turn the bars into a variety of industrial and household products.

Technology

Technology refers to all the ways people use their inventions and discoveries to satisfy their needs and desires. Ever since people appeared on the earth, they have had to work to obtain food, clothing, and shelter. They have also had to work to satisfy their desire for leisure and comfort. Through the ages, people invented tools, machines, materials, and techniques to make work easier. They also discovered water power, electricity, and other sources of power that increased the rate at which they could work. Technology thus involves the use of tools, machines, materials, techniques, and sources of power to make work easier and more productive. Modern communications and data processing also rely on technology, especially electronics.

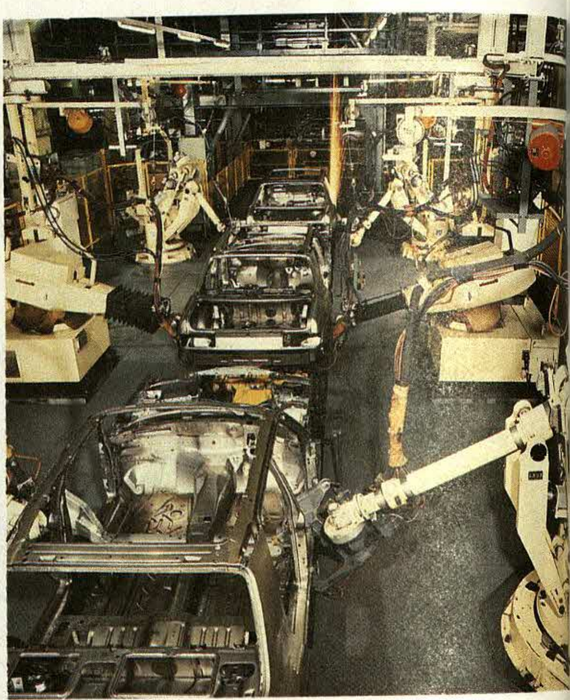
Many people call the age we live in the *age of technology.* Yet people have always lived in a technological age because they have always had to work to obtain most of life's necessities and many of its pleasures. Technology thus includes the use of both primitive and highly advanced tools and methods of work. But when people speak of technology today, they generally mean *industrial technology*—the technology that helped bring about our modern society.

Industrial technology began about 200 years ago with the development of the steam engine and power-driven machines, the growth of factories, and the mass production of goods. As industrial technology advanced, it affected more and more aspects of people's lives. For example, the development of the car influenced where people lived and worked and how they spent their leisure time. Radio and television changed entertainment habits, and the telephone revolutionized communication. Today, industrial technology helps people achieve goals that few would have thought possible a hundred years ago. It gives people the means to conquer hunger and to cure or prevent many diseases. It enables them to transport goods and passengers swiftly and easily to any place on the earth. They can even leave the earth, travel through space, and set foot on the moon.

Science attempts to explain how and why things happen. Technology is concerned with making things happen. Since 1850, science has contributed much to modern technology. However, technology has often contributed to science, for example, by providing suitable tools for observation. In addition, not all technology is based on science, nor is science necessary to all technology. For example, people made objects of iron for hundreds of years before they learned about the changes that occurred in the structure of the metal during ironmaking. But some modern technologies, such as nuclear power production and space travel, depend heavily on science.

The word *technology* is sometimes used to describe a particular application of industrial technology, such as medical technology or military technology. Each of the various specialized technologies has its own goals and its own tools and techniques for achieving those goals. The engineering profession is responsible for much of today's industrial technology (see **Engineering**).

Cars, like other inventions of technology, have changed our way of life. The convenience of car travel influences where we live and work and how we use our free time.



Assembly line production, an important method of technology, increases the amount of goods a worker can produce. Increased productivity provides more goods for more people.

Industrial technology enables people to live in greater security and comfort than ever before. But only a small part of the world's population enjoys the full benefits of advanced modern technology. In addition, nations with advanced technologies have found that certain undesirable effects, such as air and water pollution, have accompanied technological growth. Technology also enables people to produce more powerful weapons, thus adding to the destructiveness of war.

This article describes technology's benefits and undesirable effects. It also discusses the problems people face in trying to combat these effects. The development of technology largely parallels the history of inventions and discoveries, which is traced in the article on **Invention.** Detailed information on the development of technology in specific areas can be found in the *History* sections of such articles as **Agriculture, Medicine,** and **Transportation.**

Benefits of technology

Technology has helped people gain a degree of control over nature and build a civilized way of life. The earliest human beings had little control over nature. They had only simple tools and did not know how to rear animals or cultivate plants. Instead, they obtained food by hunting, fishing, and gathering. They had no permanent homes and only animal skins for protection against cold. The sun and moon were their only sources of light. About 800,000 years ago, people discovered how to make fire and so could provide themselves with heat and light wherever they went. Still, they made little noticeable impact on their environment.

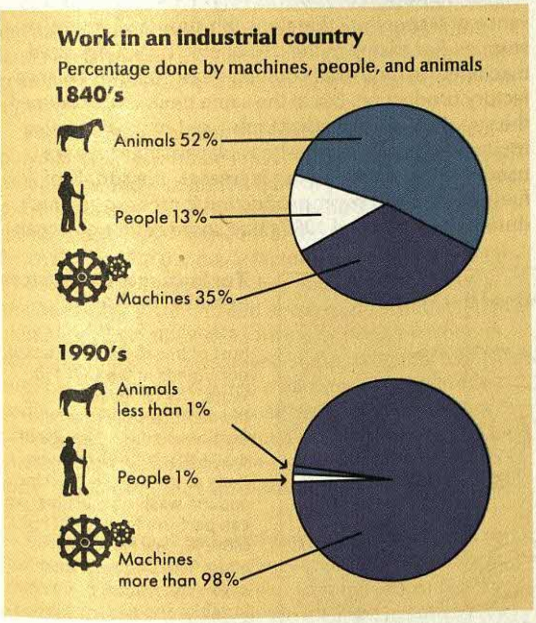
About 10,000 years ago, people learned how to rear animals and grow crops. The development of farming led them to settle down in small groups. Then, partly because agriculture produced surplus food, the population grew. In time, towns and cities developed. Many people became free to pursue kinds of work other than food production. Classes of warriors, priests, craftworkers, and merchants developed. This division of labour helped make civilization possible.

Through the ages, technology has benefited people in four main ways. First, it has increased their production of goods and services. Second, it has reduced the amount of labour needed to produce goods and services. Third, it has made labour easier. Fourth, it has given people higher living standards.

Increased production. Through technology, people have achieved a tremendous increase in the production of goods and services. In the mid-1800's, for example, people and animals were the main source of power on farms. Farmers laboured from dawn to dusk, yet one farmer produced enough food for only about four people. In the early 1900's, more and more farmers in industrial countries began using tractors and other machines powered by diesel fuel or electricity. Today, machines do most of the work on most farms in industrial countries. As a result of machinery, fertilizers, and other advances in agricultural technology, one farmer today may produce enough food for about 100 people. Similar developments have occurred in manufacturing, mining, and other industries. Most workers today produce many times more goods than they did a hundred years ago.

Reduced labour. Powered machines have increased production. But they have also reduced the amount of labour needed to produce goods and services and so

Farm machines, such as these combines, and other advances in agricultural technology make farm work easier. Such machines and methods also help farmers produce larger amounts of food.



In 1850, machines did only 35 per cent of farm and industrial work in the most developed countries. This chart shows how the 1850 percentages compare with those of 1990, when machines did over 98 per cent of the work.

Technology has enabled people to produce more goods and services with less labour. Many factories use mass production techniques. This has led to greater productivity, allowing factory workers to enjoy more leisure time.

have increased productivity. Increased productivity gives workers more leisure time. In the early 1800's, for example, most factory work was done by hand or hand-operated machines. Workers laboured 12 to 16 hours a day, six days a week. Few people were able to take a holiday. Today, powered machinery has largely replaced hand labour in factories. Many factories also use mass production techniques. As a result, the amount of labour needed to produce manufactured goods has decreased sharply. Today, factory employees in many countries work only eight hours a day, five days a week. They also receive paid leave for holidays.

Easier labour. Technology has enabled people to produce more goods and services with less labour. It has also made labour easier and safer. Coal mining provides an example. In the early 1900's, miners toiled all day with pick and shovel to produce a few tons of coal. The mines were dark, poorly ventilated, and dangerous. Today, mining is still dangerous. But better lighting and ventilation and improved safety devices have reduced the hazards. The work itself is easier and more productive. Machines perform most of the hard labour. The operator of a coal-mining machine can dig about 1 metric ton of coal a minute.

Higher living standards have resulted from the increased production of goods and services. The industrial nations produce more goods and services than other countries and have the world's highest standard of living. Most people in industrial nations are better fed, clothed, and housed and enjoy a healthier, more comfortable life than any other people in history. Above all, technology has increased human *life expectancy*—the number of years a person can expect to live. Improved public health practices have ended the plagues that once swept through many countries. Better health care and nutrition have also reduced the number of deaths among infants. In 1900, many people did not live past the age of 50. Today, many people live for more than 75 years (see **Life expectancy**).

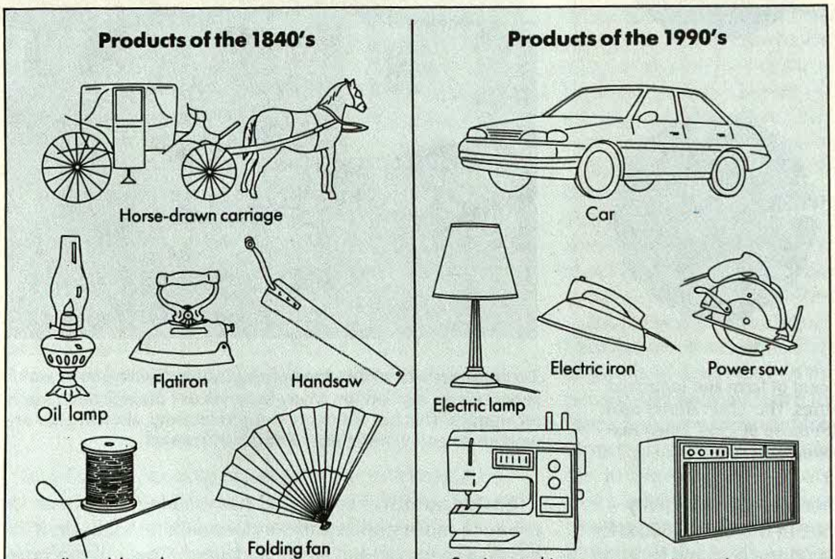
Undesirable effects of technology

The advance of technology has benefited people in numerous ways, but it has also created serious problems. These problems have arisen mainly because technologies were put to use without considering the possible harmful effects. For example, many people welcomed the development of the car in the late 1890's and early 1900's. They believed that cars would be quieter and less smelly than horses. But as more and more cars came into use, the noise of roaring traffic proved more annoying than the clatter of horse hoofs. Car exhaust fumes proved worse than the smell of horse manure. The fumes polluted the air with carbon monoxide gas and other impurities and so threatened human health. Also, cars cause even more traffic congestion in cities, and car travel can be more time-consuming than travel on horseback. The ever-increasing production of cars used up iron and other natural resources.

This section discusses four major undesirable effects of technology. They are: (1) environmental pollution, (2) the depletion of natural resources, (3) technological unemployment, and (4) the creation of unsatisfying jobs.

Environmental pollution is one of the most harmful effects of industrial technology. Most industrial countries face problems of air, water, soil, and noise pollution. Motor vehicles cause most of the air and noise pollution in these countries. But many other products as well as many processes of technology also pollute the environment. For example, certain insecticides pollute the soil and water, and endanger plant and animal life. Factory smoke and wastes also contribute greatly to air and water pollution. In many countries, power plants that burn oil or other fuels to generate electricity add millions of tons of pollutants to the air annually. Junkyards, opencast mines, logging operations, and motorways disfigure the natural environment. See the article on **Environmental pollution** for a discussion of technology's harmful environmental effects.

The depletion of natural resources. The rapid advance of technology threatens the supply of natural resources. For example, the use of electrically powered machinery in industrial countries has greatly increased factory production. But at the same time, it has reduced the supply of oil and other fuels used to produce electricity. These fuels cannot be replaced after they are used. As power production increases, the supply of fuels decreases. Power production increased so much during the 1950's and 1960's that some countries began



Technological advances around the home

Technology has brought a host of beneficial products to our homes in the past 150 years. The car enables us to travel much faster than did the horse-drawn carriage of the 1840's. With such inventions as the sewing machine and the washing machine, we can perform household tasks more rapidly and with less effort. The air conditioner makes our homes more comfortable, and electric devices such as the modern lamp are much more convenient to use than their counterparts of the 1840's.

Harmful effects of technology include the scarring of once-fertile land by opencast, or strip, mining, *left.* Streams fill with mud, the soil becomes acid, and plant and animal life vanish.

to experience a fuel and power shortage during the 1970's.

Some experts argue that the use of hydroelectricity in some countries also depletes natural resources. Usually the damming of rivers transforms fertile agricultural land into lakes and the dams' effectiveness is gradually reduced by *silting* (the build up of soil washed down in a river).

Technological unemployment is a type of unemployment that sometimes results from advances in technology. The most common type of technological unemployment occurs as a result of *mechanization*—that is, the replacement of human workers with machines. Since the late 1950's, many factories and offices have introduced computers and other machines as part of a self-operating system called *automation.* Automated machines perform many tasks formerly done by workers, and so automation has caused some unemployment. But automation also has helped a number of industries expand. As a result, these industries have been able to provide new jobs for displaced workers. Technological unemployment, however, remains a threat to workers in many industries. See **Unemployment** (Structural unemployment).

The creation of unsatisfying jobs. Some tasks required by industrial technology fail to give workers a feeling of accomplishment. For example, most factory workers make only a part of the finished product. As a result, they may lack the feeling of pride in their work that comes from creating an entire product. Many factory jobs also demand concentration. Although factory machines are safer today than in the past, many are dangerous if not operated with extreme care. The operators must be constantly alert to make sure they are operating their machines properly. But constantly tending a machine or performing the same task again and again can be monotonous as well as demanding.

The challenge of technology

Modern technology presents enormous challenges. One of the chief challenges is to combat the undesirable effects of existing technologies. Another is to prevent similar effects in the development of new technologies. Still another challenge is to spread technology's benefits to the people of developing countries.

Combating undesirable effects. Some of technology's undesirable effects are hard to remedy. For example, it is difficult to make an unsatisfying job satisfying. But automation will continue to free many workers from routine, monotonous jobs. Some of these workers may then face the hardships of unemployment. But with help from industry and government, they can be retrained to fill more highly skilled and possibly more interesting jobs. See **Automation** (Automation and jobs).

Industries can do much to combat environmental pollution and the depletion of natural resources. One way is by developing substitute technologies for those that produce harmful effects. Car makers, for example, can help curb air pollution by installing a *catalytic converter* (a type of filter) to purify the emissions from car exhaust. Manufacturers can help conserve resources by *recycling.* In recycling, raw materials are recovered from

One technology cleans up after another when a filter press squeezes solid particles out of wastewater in a chemical plant.

Recycling recovers raw materials from wastes and so helps conserve resources used by technology. The iron and steel in this discarded material is being separated for recycling.

waste products and used to make new products (see **Environmental pollution** [Recycling]).

Developing a substitute technology can be costly. An industry may need to hire additional experts or invest in expensive equipment. Most industries that develop a substitute technology pass the cost on to buyers in the form of higher prices. Some industries choose not to spend the money to develop a substitute technology. Recycling materials can also be more costly than the use of traditional resources. But in many cases, the choice is too serious to be left to industries because the health of an entire community may be affected.

Substitute technologies may also have undesirable effects. For example, nuclear power plants have several advantages over fuel-burning plants in producing electricity. Nuclear plants can produce large amounts of electricity using only small amounts of raw materials. They also do not pollute the air as do fuel-burning plants. But nuclear plants release hot water into lakes and rivers. This causes *thermal pollution,* which harms water plants and animals. Scientists and engineers are working to solve this problem. For example, many nuclear plants have installed *cooling towers,* which use air to cool the hot water they produce. Some companies recover the waste heat produced by industrial processes for the heating of buildings.

Preventing undesirable effects. Some experts believe that most harmful effects of technology can be prevented. According to this view, any proposed large-scale technology should be thoroughly tested and then evaluated before it is put into use. Such an evaluation is called a *technology assessment.*

The purpose of an assessment is to discover in advance all the possible good and bad effects that a new technology may have on society and the environment. An assessment might show that the benefits of a new technology outweigh any undesirable effects. Or it might show that the undesirable effects would be so harmful that they outweigh any benefits.

Some experts doubt the value of technology assessment. They believe that it is not possible to discover all the undesirable effects of a technology before it is put into use. They also fear that technology assessments will block scientific and technological progress.

Spreading the benefits of technology. Technology's benefits are limited largely to the industrial nations. But even in these nations, the benefits of technology are not evenly distributed. Many families in the industrial countries lack all but the bare necessities of life.

The developing nations of the world enjoy few of technology's benefits. Also, the people of these countries want the goods and services that technology has made available to industrial nations. The transfer of technological knowledge from industrial to developing nations is one of today's chief challenges.

As technology advances in developing countries, it will probably produce some harmful effects. Advanced technology will probably also continue to create problems in the industrial countries. But technological achievements in the past show that people have the intelligence, imagination, and inventive skill to deal with present and future problems created by technology.

Related articles in ***World Book.*** See **Engineering, Industry, Invention,** and **Manufacturing** with their lists of *Related articles.* See also the following articles:

Agriculture
Assembly line
Automation
Building trade
Environmental pollution
Factory
Industrial Revolution
Labour force
Machine
Machine tool
Mass production
Mining

Outline

I. Benefits of technology
- A. Increased production
- B. Reduced labour
- C. Easier labour
- D. Higher living standards

II. Undesirable effects of technology
- A. Environmental pollution
- B. The depletion of natural resources

  - C. Technological unemployment
  - D. The creation of unsatisfying jobs
- **III. The challenge of technology**
  - A. Combating undesirable effects
  - B. Preventing undesirable effects
  - C. Spreading the benefits of technology

Questions

In what four main ways has technology aided people?
How does technology differ from science?
What is *technology assessment*? What is its main purpose?
Why is less labour needed to manufacture goods today than in the past?
What are four of the major undesirable effects of technology?
What challenges does modern technology present?
When did industrial technology begin?
What is technological unemployment?
What are some of the ways in which industrial technology has affected people's lives?
Why did many people welcome the development of the car in the late 1890's and early 1900's?

Tectonics. See **Plate tectonics.**

Tecumseh (1768?-1813) was an outstanding leader of the eastern American Indian tribes in the late 1700's and early 1800's. He worked to unite all the American Indian tribes into a single alliance that would defend Indian lands against invasion by white people. Tecumseh means *shooting star* or *meteor.*

Tecumseh is believed to have been born at Old Piqua, a Shawnee village northeast of present-day Dayton, Ohio, U.S.A. His father and two brothers were killed in battles with the American colonists.

White settlers were rapidly taking Indian lands, and Tecumseh and his brother Tenskwatawa began a crusade to keep land for the Indians. Tenskwatawa, known as the Shawnee Prophet, led a religious revival (see **Shawnee Prophet**). Tecumseh, a strong warrior and gifted orator, led in politics and war. He travelled frequently from his home to visit other tribes east of the Mississippi River. The two men did much to restore the culture of the Indians of the Ohio River Valley region.

Tecumseh condemned a treaty that William Henry Harrison, then governor of the Indiana Territory, made with the Indians. His action led to the Battle of Tippecanoe in November 1811. See **Indian wars** (Other Midwestern conflicts [1790-1832]).

Tecumseh joined the British armies to fight the Americans in the War of 1812 and commanded the Indian allies. He was killed leading his forces in Canada.

Lithograph (1841) by Nathaniel Currier

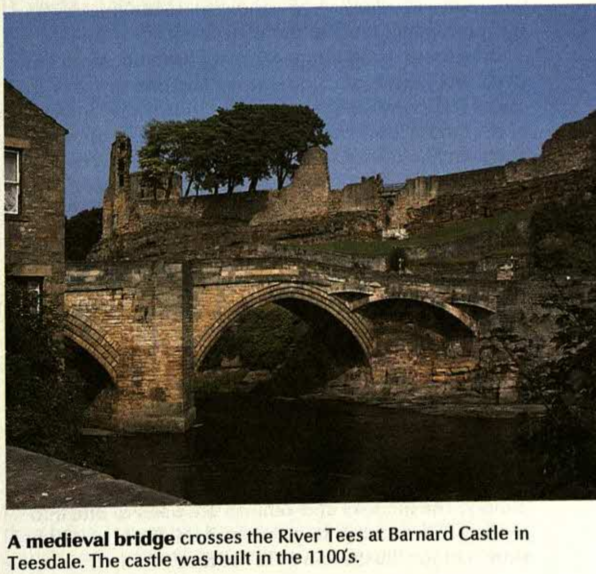
Tecumseh was an American Indian leader who fought to defend Indian lands against invasion by white people. He allied his forces with the British army against the Americans during the War of 1812 and died at the Battle of the Thames River, *above.*

Tedder, Arthur William (1890-1967), Baron Tedder of Glenguin, became a marshal of the Royal Air Force of the United Kingdom in 1945. Tedder served in the Royal Air Force during World War I (1914-1918) and World War II (1939-1945). He was named deputy supreme commander in World War II. He later became deputy supreme commander of the North Atlantic Treaty Organization (NATO) forces in Europe. Tedder was knighted in 1942 and made a baron in 1946. He was born in Stirlingshire (now Central Region), Scotland.

Teenager. See **Adolescent.**

Tees is a river in northeastern England. It rises in Cumbria among the Pennines and flows southeast via the Durham towns of Middleton in Teesdale and Barnard Castle, to the busy industrial centres of Stockton-on-Tees and Middlesbrough, in Cleveland. The Tees then swings northeast, and the river flows into the North Sea at Teesmouth. The total length of the Tees is about 112 kilometres. It is navigable as far as Stockton.

Teesdale (pop. 24,200) is a local government district in Durham. It is administered from the picturesque town of Barnard Castle, above the River Tees. Another town is Middleton in Teesdale, once a centre of lead mining. Barnard Castle and Staindrop have ruined medieval castles. Agriculture, notably sheep and cattle rearing and arable farming, predominates. See also **Durham.**


A medieval bridge crosses the River Tees at Barnard Castle in Teesdale. The castle was built in the 1100's.

Teeth

Teeth are hard, bonelike structures in the upper and lower jaws of human beings and many kinds of animals. They are the hardest parts of the body.

People use their teeth chiefly to chew food. Chewing is the first step in the process of *digestion.* Digestion begins as the teeth chop and grind chunks of food into smaller pieces. As the teeth chew the food, it is mixed with *saliva,* a liquid produced in the mouth. The food becomes a moist pulp, which is easy to swallow. The food is further broken down in the stomach and the small intestine, where it is absorbed by the blood. The blood carries the digested food to all parts of the body. Without teeth, people could not eat foods that must be chewed. They could only swallow soft foods and liquids.

Teeth also play an important part in speech. The teeth and tongue are used together to form many sounds that make up words. To produce the *th* sound, for example, the tip of the tongue is placed against the upper front teeth. A person who lacks these teeth may be unable to make the sound. Teeth also help support the muscles around the mouth and so contribute to a person's appearance. People who have lost their teeth lack this support. Unless they wear artificial teeth, they may have deep, saggy lines around the mouth.

Like human beings, most animals use their teeth to chew food. They also use their teeth to obtain food. Many animals that eat plants tear off the leaves or stalks of the plants with their teeth. Most meat-eating animals use their teeth to seize and kill prey.

This article chiefly discusses human teeth. The last section of the article describes the differences in the teeth of various kinds of animals.

Kinds of teeth

Human beings grow two sets of teeth: (1) deciduous teeth and (2) permanent teeth. The individual deciduous teeth appear and fall out gradually early in life. They are replaced, one by one, by the permanent teeth. See the table *Ages at which teeth appear* for when deciduous and permanent teeth generally appear.

Deciduous and permanent teeth have the same basic structure. Each tooth has a *crown* and one or more *roots.* The crown is the part of the tooth that can be seen in the mouth. Bone and gums cover the root or roots. The roots hold the tooth in a socket in the jawbone.

Deciduous teeth are also called *baby teeth, milk teeth,* or *primary teeth.* They start to form about 7½ months before a baby is born. They begin as oval or round swellings called *buds,* which gradually develop into teeth. When a baby is born, parts of all the deciduous teeth are present deep within the jaws. As the teeth grow, they push through the gums. This process is called *eruption* or *teething.* Babies begin to teethe at about 6 to 9 months of age. Most children have all their deciduous teeth by about 2 years of age.

There are 20 deciduous teeth, 10 in each jaw. They consist of three kinds of teeth: (1) incisors, (2) canines, and (3) molars. Each jaw has 4 incisors, 2 canines, and 4 molars. The incisors and canines are used to bite into food, and the molars to grind food. All these teeth are shown in the illustration *Kinds of teeth.*

The deciduous teeth help the permanent teeth erupt in their normal positions. Most of the permanent teeth form near the roots of the deciduous teeth. When a child is about 3 years old, the roots of various deciduous teeth begin to dissolve slowly. By the time a permanent tooth is ready to erupt, the root of the deciduous tooth has completely dissolved. The crown of the tooth then becomes loose and falls out.

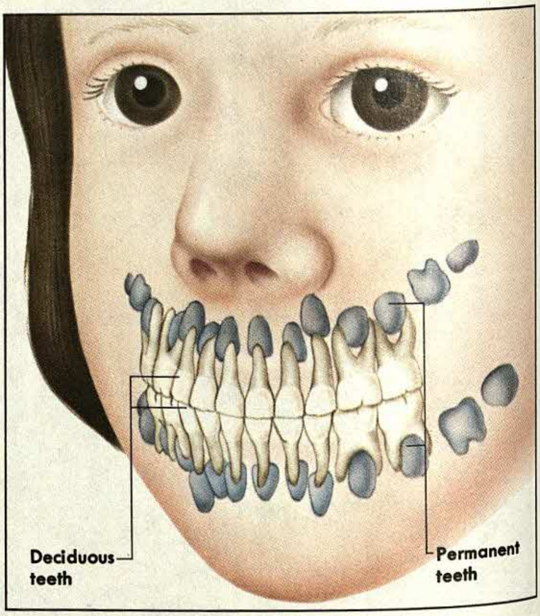
Permanent teeth, like deciduous teeth, begin to develop before birth. But most of their growth occurs after birth. The permanent teeth begin to erupt after the deciduous teeth start to fall out.

The first permanent teeth appear when a child is about 6 or 7 years old. Between the ages of 6 and 12, a child has some permanent and some deciduous teeth in the mouth. The last permanent teeth erupt when a person is 17 to 21 years old.

There are 32 permanent teeth, 16 in each jaw. They are larger than the deciduous teeth and consist of four kinds of teeth. The four kinds are (1) incisors, (2) canines, (3) premolars, and (4) molars. Each jaw has 4 incisors, 2 canines, 4 premolars, and 6 molars. The following discussion describes the four kinds of permanent teeth. Their positions in the mouth are shown in the illustration *Kinds of teeth.*

Incisors are the chief biting teeth. They have a sharp, straight cutting edge. In most cases, incisors have one root. The central incisors of the lower jaw are the smallest permanent teeth.

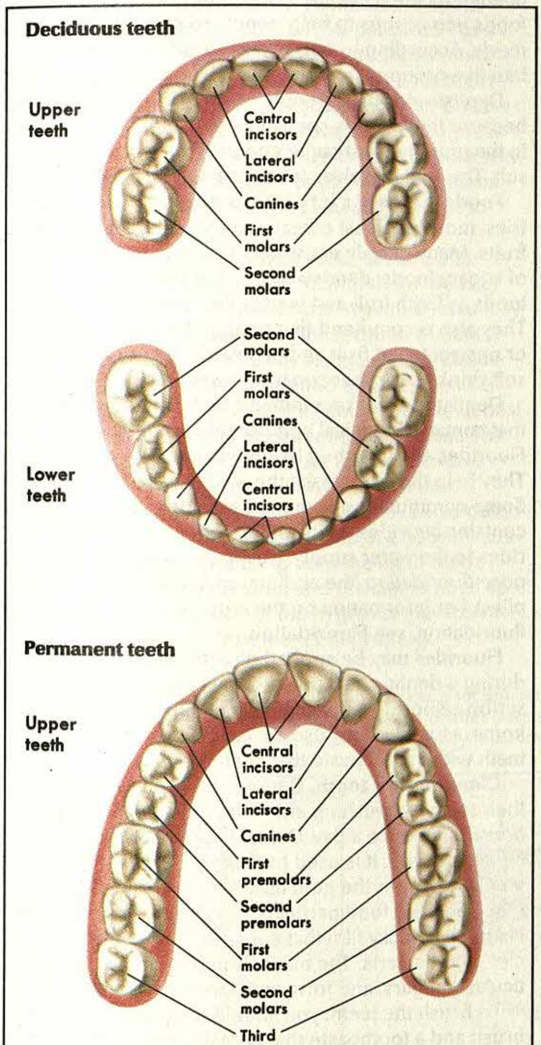
Canines are used with the incisors to bite into food. They are also used to tear off pieces of food. The name for these teeth comes from another word for *dog*—that is, *canine.* The canine teeth resemble a dog's fangs. They have a sharp, pointed edge and one root. Canines are



The teeth of a child. By the time a child is about 4 years old, most of the permanent teeth have formed within the jaws near the roots of the deciduous teeth. The deciduous teeth, all of which have erupted by about age 2, will gradually fall out and be replaced, one by one, by the permanent teeth.

Kinds of teeth

The illustrations below show the kinds of deciduous and permanent teeth and their positions in the mouth.



Ages at which teeth appear*

Deciduous teeth:	**Lower teeth**	**Upper teeth**
Central incisors	6 months	7 months
Lateral incisors	7 months	9 months
Canines	16 months	18 months
First molars	12 months	14 months
Second molars	20 months	24 months

Permanent teeth:	**Lower teeth**	**Upper teeth**
Central incisors	6-7 years	7-8 years
Lateral incisors	7-8 years	8-9 years
Canines	9-10 years	11-12 years
First premolars	10-12 years	10-11 years
Second premolars	11-12 years	10-12 years
First molars	6-7 years	6-7 years
Second molars	11-13 years	12-13 years
Third molars	17-21 years	17-21 years

* The ages given are approximate. In many cases, individual teeth may erupt at an earlier or later age.

also called *cuspids* or *dogteeth.* The upper canines are sometimes known as *eyeteeth.*

Premolars are used to crush and grind food. They have a broad, lumpy top instead of a sharp biting edge. The small surface lumps are called *cusps.* The cusps enable the teeth to mash pieces of food.

Premolars are sometimes called *bicuspids* because, in most cases, they have two cusps. The prefix *bi* means *two.* The first upper premolars normally have two roots. The other premolars have one root. The premolars erupt in the place of the deciduous molars.

Molars, like premolars, are used to grind food. They are shaped much like premolars but are larger. The various molars normally have three to five cusps and two or three roots.

The permanent molars do not form beneath any of the deciduous teeth. They develop as the jaws grow, which makes space for them. Some adults lack one or more of the third molars, which are commonly called *wisdom teeth.* In many cases, the jaws do not grow large enough to provide space for the wisdom teeth. As a result, the wisdom teeth may become *impacted*—that is, wedged between the jawbone and another tooth. The wisdom teeth must then be removed.

Parts of a tooth

A tooth consists of four kinds of tissues. They are (1) pulp, (2) dentine, (3) enamel, and (4) cementum. Connective tissue surrounds the root of the tooth. This tissue, called the *periodontal ligament,* holds the root in the socket in the jaw.

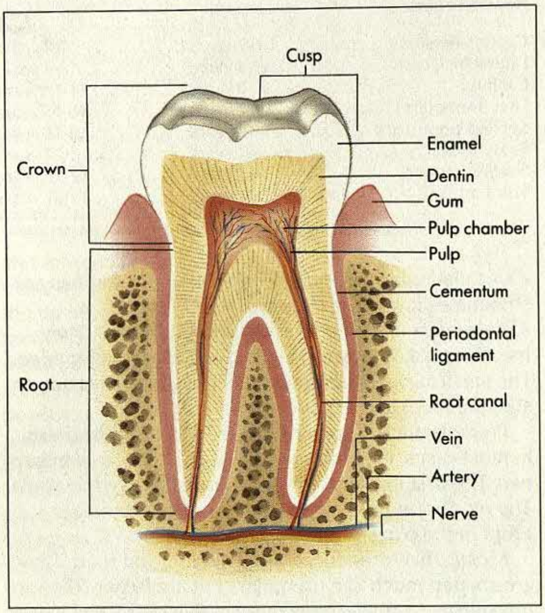
Pulp is the innermost part of a tooth. It consists of connective tissue, blood vessels, and nerves. The blood vessels nourish the tooth. The nerves transmit sensations of pain to the brain.

The pulp has two parts, the *pulp chamber* and the *root canal.* The pulp chamber lies in the crown of the tooth. The root canal lies in the root of the tooth. Blood vessels and nerves enter the root canal through a small hole at the tip of the root. They extend through the root canal and into the pulp chamber.

Dentine is a hard, yellow substance that surrounds the pulp. It makes up most of a tooth. Dentine is harder than bone. It consists mainly of mineral salts and water but also has some living cells.

Parts of a tooth

The *crown,* or visible part of a molar tooth, includes projections called *cusps.* The *root* extends into the bone of the jaw. A tissue called *dentine* makes up most of the tooth. A layer of *enamel* covers the dentine of the crown, and *cementum* overlies the dentine of the root. Within the dentine lies the *pulp,* including the *pulp chamber* and the *root canal,* through which blood vessels and nerves enter the tooth. The *periodontal ligament* surrounds the root and holds the tooth in its socket.



Enamel overlies the dentine in the crown of the tooth. It forms the outermost covering of the crown. Enamel is the hardest tissue in the body. It enables a tooth to withstand the pressure placed on it during chewing. Enamel consists of mineral salts and a small amount of water. Enamel is white but transparent. The yellow colour of the dentine shows through the enamel, and so most teeth appear slightly yellowish.

As a person grows older, small amounts of enamel begin to wear away. This process, called *attrition,* results from the use of the teeth over a long period. As the enamel wears away, the dentine becomes exposed.

Cementum overlies the dentine in the root of the tooth. In most cases, the cementum and enamel meet where the root ends and the crown begins. As the surface of the tooth wears away, the tooth grows farther out of its socket, exposing the root. These areas may then become more sensitive to hot and cold liquids. Cementum is about as hard as bone. Like dentine and enamel, it consists mainly of mineral salts and water.

Periodontal ligament consists of small fibres. These fibres extend through the cementum and into the bony socket, which is called the *alveolus.* Besides anchoring the tooth in the alveolus, the periodontal ligament serves as a shock absorber during chewing.

Care of the teeth and gums

Most cases of tooth decay and gum disease could be prevented if people took proper care of their teeth and gums. Proper care requires (1) a good diet, (2) cleaning the teeth after eating, and (3) dental checkups.

A good diet. Dentists advise people to eat well-balanced meals. Such meals include a variety of foods and provide the *nutrients* (nourishing substances) needed by the teeth and gums. Nutrition experts divide foods into groups to help people to plan well-balanced meals. According to one system, foods are classified into five groups.

Dentists also urge people to eat fewer sugary foods because these foods contribute to tooth decay. Bacteria in the mouth digest sugar and produce an acid as a result. The acid dissolves tooth enamel, forming a cavity.

Foods that have a lot of sugar include sweets, pastries, most breakfast cereals, and sweetened canned fruits. Many people eat sugary foods as snacks. In place of sugary foods, dentists advise people to snack on such foods as fresh fruit and vegetables, cheeses, and nuts. They also recommend that people drink skimmed milk or unsweetened fruit and vegetable juices instead of soft drinks and other sugar-sweetened beverages.

Dentists further recommend that children drink water that contains chemical compounds called *fluorides.* Fluorides are absorbed by the enamel as the teeth grow. They help the teeth resist the acid that forms cavities. Some communities have a water supply that naturally contains fluorides. Many other communities add fluorides to the water supply. However, some people oppose *fluoridation* (the addition of fluorides to water supplies). For information on the arguments for and against fluoridation, see **Fluoridation.**

Fluorides may be applied directly to a child's teeth during a dental checkup. In some cases, dentists prescribe a fluoride substance that children can apply at home. Most dentists also advise children to brush their teeth with a toothpaste that contains fluorides.

Cleaning the teeth. Dentists advise people to clean their teeth by brushing after every meal and by using *dental floss* once a day. Dental floss is a thin thread that comes in a roll. It is used to clean the areas between teeth and under the gum line. Brushing and flossing remove trapped food particles and *plaque* from the teeth. Plaque is a sticky film that consists of saliva, food particles, and bacteria. The bacteria digest certain foods, particularly sugars, and form an enamel-dissolving acid.

To brush the teeth, you should use a small, soft toothbrush and a toothpaste that contains fluorides. There are several methods of brushing. You should use the one recommended by your dentist. One commonly recommended method is to place the brush against the teeth at a slight angle, with the bristles pointed toward the gums. Brush the upper teeth with a downward, sweeping motion. Brush the lower teeth with an upward, sweeping motion. Clean both the outside and the inside surfaces of the teeth in this way. Use a scrubbing motion to clean the biting surfaces of the premolars and molars. Lastly, brush the tongue to remove food particles and bacteria, which contribute to bad mouth odours. Then rinse the mouth thoroughly with water or a mouthwash.

To floss the teeth, cut a piece of floss about 45 centimetres long from the roll. Wrap one end of the floss around each middle finger. Using the index fingers and thumbs, gently guide the floss between two teeth. Then pull the floss up and down, cleaning the sides of both teeth and the areas around the gum line.

Some people use *disclosing tablets* to see if any areas of the teeth remain unclean after brushing and flossing. Disclosing tablets contain a red or purple dye. When you chew a tablet, the dye sticks to unclean areas of the teeth. You can then rebrush and refloss these spots.

Dental checkups. Dentists advise people to have a dental checkup at least once a year. Children should start going to a dentist after all their deciduous teeth have erupted. Dentists can recognize and treat diseases of the teeth and gums at an early stage, before the diseases cause serious damage. Dentists also provide services that help prevent diseases of the teeth and gums. Many dentists employ a licensed *dental hygienist* to help them in their work.

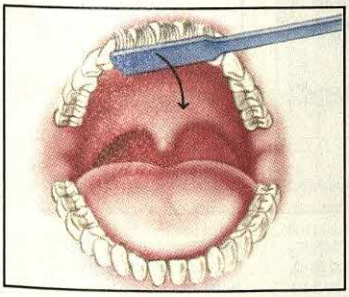
During a checkup, the dentist looks at the teeth, gums, and other tissues inside the mouth for signs of diseases. The dentist—or the dental hygienist—also may X-ray the teeth. X rays can show the location of dental decay that cannot be seen. They also show any abnormal conditions of the jawbones and other tissues that support the teeth. Based on the examination, the dentist may decide to fill cavities or plan other treatment. The dentist or hygienist then cleans the teeth to remove plaque and *calculus,* a hard, yellowish substance formed by the buildup of plaque. Calculus is also called *tartar.* After the teeth have been cleaned, a fluoride substance is sometimes applied to help the teeth resist decay. Generally, only children and teenagers need applications of fluorides. Lastly, the hygienist may instruct the patient on how to clean the teeth properly.

Diseases and defects of the teeth

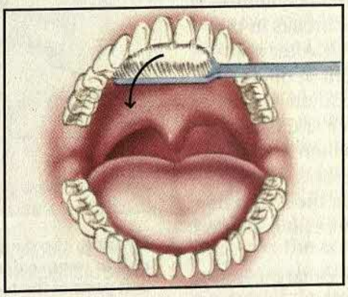
Dental decay, also called *caries,* is the most common disease of teeth. In many industrial countries, dental decay is becoming less common, especially among children. In the developing world, where previously many people were free of decay all their lives, it is increasingly common. Abnormal positioning of teeth, called *malocclusion,* is common among younger people. Diseases of the gums, called *periodontal* diseases, are the chief dental disease throughout the world. A much less common but serious disease is oral cancer, which each year affects about 4 in every 100,000 people in most Western countries, and about 40 in every 100,000 in the Indian subcontinent, parts of South-East Asia, South America and the Pacific islands. The following discussion describes the causes and treatment of (1) dental decay, (2) malocclusion, (3) periodontal diseases, and (4) oral cancer.

Dental decay is a complex process that involves plaque, bacteria, and food. Proteins from saliva form an invisible film on the teeth. Bacteria and food particles stick to this, forming plaque. The bacteria digest *carbohydrates* (sugars and starches) in food and produce an acid. The acid slowly dissolves enamel, eventually producing a cavity. In its early stages, this decay can be repaired naturally. Repair will result if the acid attack is controlled by good oral hygiene, reducing the frequency of sugary and starchy snacks, and if enough fluoride reaches the decay area. Uncontrolled decay may

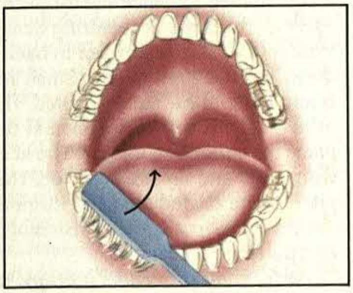
How to brush your teeth Use a small, soft toothbrush and a toothpaste that contains fluorides. Place the brush against the teeth at a slight angle, with the bristles pointed toward the gums. The illustrations below show one of the brushing methods commonly recommended by dentists.



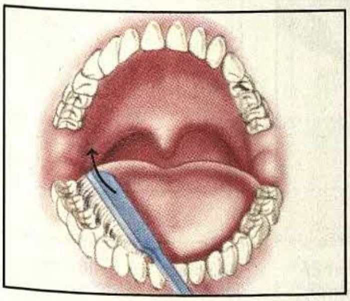
Outside surfaces of upper teeth. Use a downward, sweeping motion.



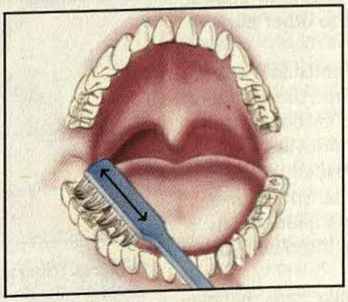
Inside surfaces of upper teeth. Use a downward, sweeping motion.



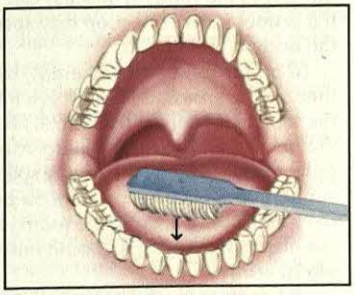
Outside surfaces of lower teeth. Use an upward, sweeping motion.



Inside surfaces of lower teeth. Use an upward, sweeping motion.



Biting surfaces of premolars and molars. Scrub back and forth.



The tongue. Brush to remove food particles and bacteria.

progress through enamel to dentine. When the decay reaches the pulp, a toothache may result.

The *occlusal* (biting) surfaces of the premolars and molars are prone to decay because they have many small pits and cracks which harbour plaque. This type of decay may be prevented by applying a *sealant.* The sealant is a plastic which is bonded to the occlusal surface.

Dentists have several methods of treating decay, depending on the severity. For early decay, most dentists advise on methods for reversing the decay. When action by a dentist is needed, the most common treatments include (1) filling a cavity, (2) performing root canal therapy, (3) crowning a tooth, and (4) removing and replacing teeth. Before beginning any of these procedures, the dentist usually injects a *local anaesthetic* (painkilling drug) into the gums near the nerves of the tooth. In some procedures, *electronic anaesthesia* may be used. This technique sends gentle electronic impulses to the brain through *electrodes* (conductors) positioned in the mouth. These impulses block pain signals. The patient uses a handheld remote control unit to increase or decrease the amount of anaesthesia.

Filling a cavity. To fill a cavity, the dentist first removes the decayed and soft parts of the tooth, using small hand instruments or an air-powered or electric drill. The dentist then makes tiny undercuts or ledges in the hole with a high-speed drill. These undercuts help hold the filling, which is not adhesive. The filling is packed into the hole and allowed to harden slightly. The dentist then carves the filling to restore the original shape of the tooth. In most cases, dentists fill cavities with *silver amalgam* or gold. Silver amalgam consists of silver, mercury, and a small amount of copper and tin. Another method of filling cavities uses a plasticlike *resin* that is shaded to match the tooth colour. This method is particularly useful in repairing decay or breaks in the front teeth, but can be used in back teeth. After any decay has been removed, a small amount of dilute acid is applied to the area to be filled. The acid etches or grooves the surrounding enamel surface and is left in place for about one minute. The acid is then rinsed off with water and the area is dried. The resin is then applied to the etched area and formed into the shape of the cavity or break. After hardening, the resin is shaped and polished with a drill.

Performing root canal therapy. Root canal therapy is the removal of the pulp of a tooth. It is performed if the pulp has become infected. When decay extends into the pulp, a small sac of pus, called an *abscess,* may form at the end of the root. An abscess can be extremely painful. If it is not treated, infection may spread to other parts of the body.

To perform root canal therapy, the dentist first anaesthetizes the area and then drills a hole into the crown of the tooth. The dentist uses small files to reach through the hole and clean out the pulp. After removing the pulp, the dentist fills the empty space, usually with a rubberlike substance called *gutta-percha.* Sometimes, the hole in the crown of the tooth is then filled. But in the majority of cases, the tooth must be fitted with an artificial crown.

Crowning a tooth. Crowns are toothlike caps that may be made of metal, porcelain, or plastic. They are used when the natural crown is so badly damaged that it does not have enough healthy tissue to hold a filling.

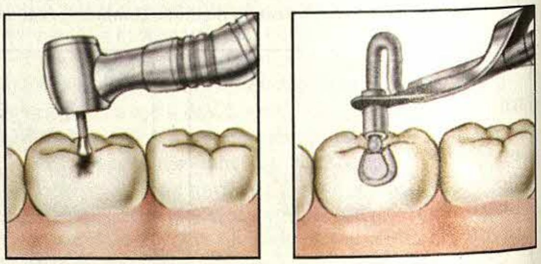
To crown a tooth, the dentist first anaesthetizes the area and then prepares the natural crown by grinding it down slightly. Next, the dentist covers the prepared tooth and the teeth next to it with a jellylike material. After this material hardens, it is removed from the patient's mouth and serves as an *impression* (mould). The dentist also makes an impression of the teeth in the opposite jaw that press against the prepared tooth and the teeth next to it. The impressions are used to make a plaster reproduction of the prepared tooth and other teeth. Dental technicians then produce a crown, using the plaster reproduction as a model. They must make sure that the crown not only fits the prepared tooth but also fits in place with the other teeth.

Meanwhile, a temporary crown is placed on the tooth. When the permanent crown is ready, the dentist removes the temporary crown and cements the permanent one onto the tooth.

Crowns can also be made by a computerized method that eliminates the need for impressions and plaster models. This method is called *computer-aided design and computer-aided manufacturing* (CAD/CAM). The dentist uses an optical probe system to record electronic images of the tooth. This information is entered into a computer, which designs an electronic model of

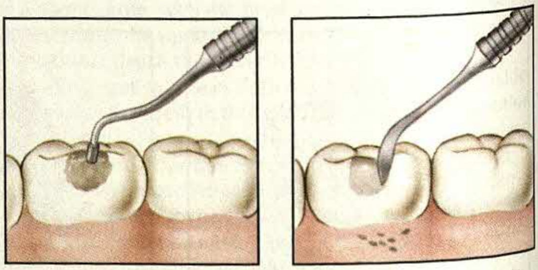
Filling a cavity

These illustrations show how a dentist fills a cavity. The dentist usually begins by injecting a drug called an *anaesthetic* into the gums near the tooth. The anaesthetic prevents the patient from feeling the pain that drilling might produce.



Drilling. The dentist uses a drill to remove decayed and soft parts of the tooth and to form undercuts or ledges that will help hold the filling.

Filling. An instrument is used to place filling material in the hole. Silver amalgam, made from silver, mercury, copper, and tin, is a common filling.



Packing. Using another instrument, the dentist firmly packs the filling into the hole. The filling is then allowed to harden slightly.

Shaping. The dentist carefully carves the filling to restore the original shape of the tooth. Finally, any rough edges are smoothed down.

the tooth. The design is then transferred through the computer to the head of a cutting tool, which prepares the crown to exactly fit the tooth.

If a tooth is only slightly damaged, a dentist may cover the tooth with thin porcelain sheets called *veneers.* The veneers are made to match the shape and colour of a tooth and are bonded to the tooth using a cementlike material. They are used primarily to improve the appearance of front teeth.

Removing and replacing teeth. In severe cases of dental decay, a dentist may remove one or more teeth and replace them with artificial ones. But artificial teeth do not function as well as natural teeth. Dentists therefore remove teeth only in those cases where no other method of treatment is considered advisable.

To remove a tooth, a dentist first anaesthetizes the area. The dentist uses an instrument that resembles a pliers to grip the crown of the tooth and loosen the root from the socket. Both the crown and the root are then removed. After the gums heal, the patient can be fitted with an artificial tooth.

Artificial teeth are made from impressions taken of the patient's mouth. In most cases, the teeth are made of plastic. The most common types of artificial teeth are *bridges, partial dentures,* and *full dentures.* Bridges are permanently fixed in the mouth, but partial dentures and full dentures are removable. Bridges are used when only a few teeth are missing. They consist of one or more artificial teeth with a metal or porcelain crown on each side. The crowns fit over the adjoining natural teeth, which must be prepared to hold the crowns. Partial dentures are also used to replace only a few missing teeth. A partial denture has metal clasps that hook around nearby teeth and hold the denture in place. Full dentures are used when all the teeth of one or both jaws are missing. In a full denture, the artificial teeth are attached to a plastic base that fits over the ridge left after the teeth have been removed. In the upper jaw, the plastic base also covers the roof of the mouth.

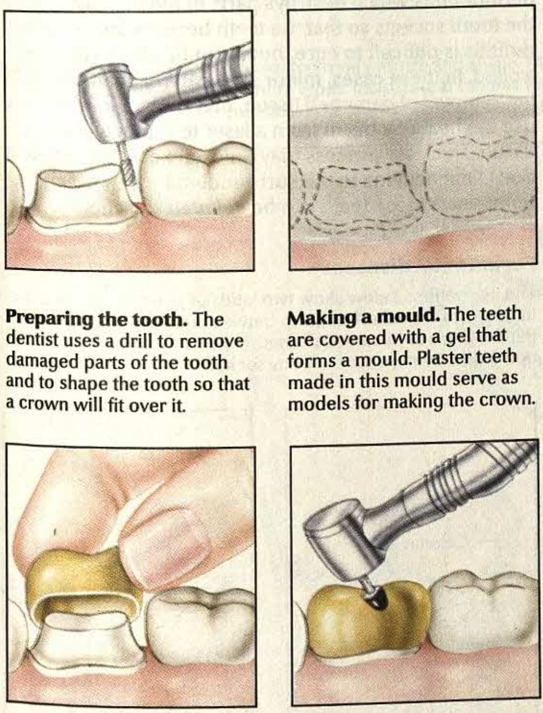
Another method of replacing one or more missing teeth involves the use of *dental implants.* In the most common implant procedure, metal or ceramiclike cylinders, called *fixtures* or *root forms,* are surgically implanted in the area of the jaw where the teeth are missing. After the area has healed, artificial teeth are permanently attached to the root forms. Implants cannot be used if the jaw area is severely damaged.

Malocclusion is the failure of the teeth in the upper and lower jaws to meet properly when a person bites. Normally, the upper front teeth should slightly overlap the lower front teeth. There are three main types of malocclusions, *overbite, underbite,* and *crowding.* In overbite, the upper front teeth stick out too far over the lower front teeth. This defect is commonly called *buck teeth.* In underbite, the lower front teeth extend in front of the upper ones. Many people have the correct *occlusion* (bite), but their teeth are crowded. Crowding is the most common malocclusion.

Malocclusion has various causes. In some cases, a deciduous tooth falls out before a permanent tooth is ready to erupt. The nearby teeth then gradually move into the open space and prevent the permanent tooth from erupting in the correct position. In other cases, the

Crowning a tooth

A crown is a toothlike cap made of metal, porcelain, or plastic, which is cemented onto a damaged tooth. It is used when a tooth does not have enough healthy tissue to hold a filling.

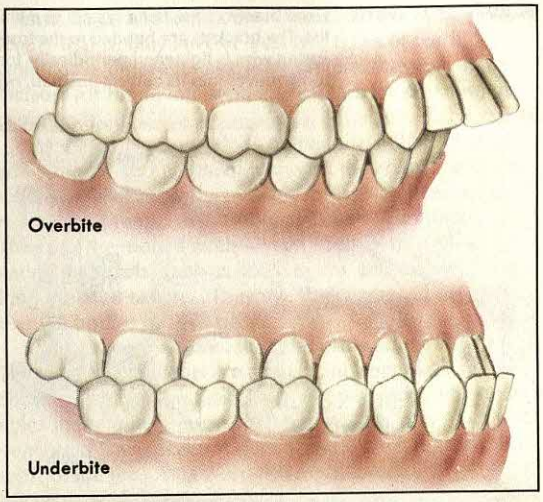


Preparing the tooth. The dentist uses a drill to remove damaged parts of the tooth and to shape the tooth so that a crown will fit over it.

Making a mould. The teeth are covered with a gel that forms a mould. Plaster teeth made in this mould serve as models for making the crown.

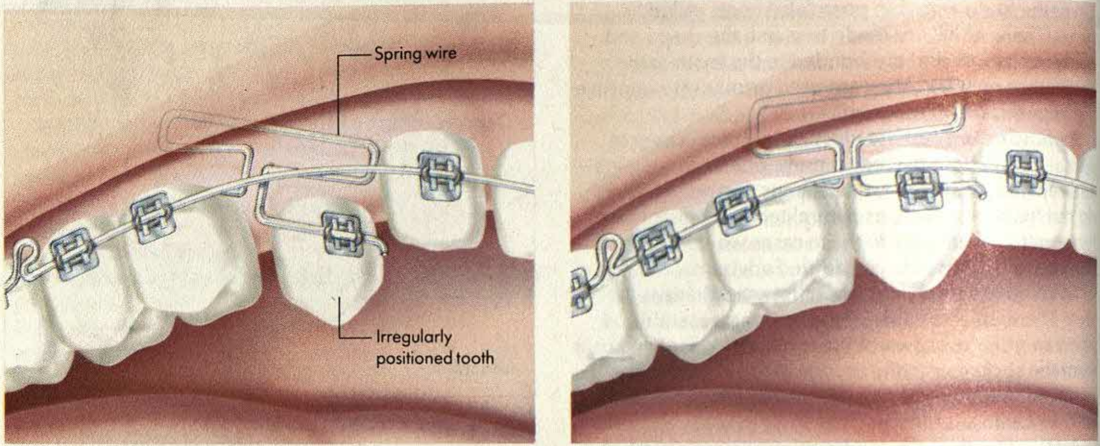
Cementing the crown. The crown must fit the prepared tooth and also fit in place with the teeth next to it and those in the opposite jaw.

Final fitting. The dentist may use a small grinding stone to make minor adjustments in the crown so that it will fit properly.



Malocclusion is the failure of the upper and lower teeth to meet properly when a person bites. Two kinds of malocclusions are *overbite* and *underbite.* In overbite, the upper front teeth stick out farther than normal over the lower ones. In underbite, the lower front teeth extend in front of the upper ones.

How braces work Fixed braces consist of a system of metal brackets and wires that can only be removed by the dentist. The brackets are bonded to the front surface of each tooth and connected by wires, *left.* A spring wire is tightened periodically, forcing the irregularly positioned tooth to move. In time, the tooth moves into its correct position, *right.*



permanent teeth are too large for the jaw and crowd one another. The edges of some teeth may then overlap, or one tooth may grow above another. In still other severe cases, the jaws do not grow properly.

Malocclusion prevents the teeth from functioning normally when a person chews food. It also may affect the way a person speaks. In addition, severe malocclusion contributes a little to the development of dental decay and periodontal diseases, partly because irregularly positioned teeth are hard to clean.

Most cases of malocclusion can be corrected with *braces.* These can be wires and springs fixed to a plastic plate that can be removed from the mouth by the patient, or metal or clear ceramic brackets bonded on the front surface of each tooth and connected by wires. These can be removed only by a dentist. The wires are tightened periodically in order to force the teeth to move into the correct position. But the teeth must be moved slowly, and so the treatment may be extended over a year or more. In some cases, one or more teeth must be removed to allow enough space for the others to move into a normal position.

Periodontal diseases are caused chiefly by the build-up of plaque and calculus between the gums and teeth. The plaque and calculus irritate the gums, causing them to become inflamed. In time, the bone supporting the teeth may become inflamed. The best way to prevent plaque from building up under the gum line is by flossing daily. The gums can also become irritated by habitually breathing through the mouth, smoking or chewing tobacco, brushing improperly, or wearing ill-fitting dentures. Irregularly positioned teeth can also irritate the gums.

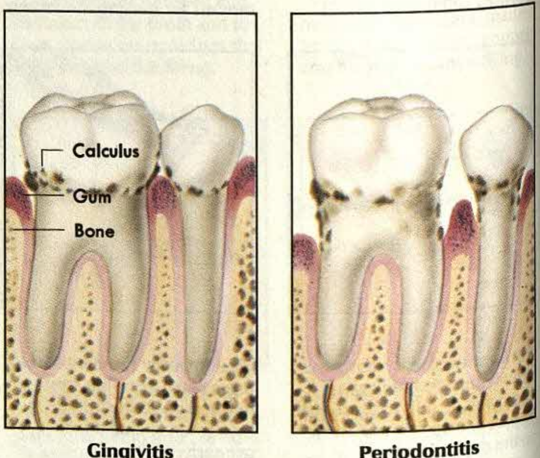
There are three main kinds of periodontal diseases. They are (1) gingivitis, (2) periodontitis, and (3) Vincent's infection.

Gingivitis is an inflammation of the *gingivae* (gums). The gingivae become red and swollen and bleed easily when brushed or prodded. Dentists treat gingivitis by *scaling* (cleaning) the teeth and gums to remove plaque and calculus. They also instruct patients on how to clean the teeth and on how to massage the gums.

Periodontitis, which used to be called *pyorrhea,* is a long-standing inflammation of the tissues that support the teeth. Like gingivitis, it is caused by irritation from plaque below the gum line. Periodontitis usually progresses very slowly and can be controlled by good oral hygiene and scaling. Some people have more active periodontitis which destroys parts of the bony walls of the tooth sockets so that the teeth become loose. Periodontitis is difficult to cure, but it can be effectively controlled. In these cases, minor surgical treatment, involving removal of damaged tissue, may help. Some dentists use the heat of a beam from a laser to remove infected tissue. The laser process may quicken healing because it does little damage to the surrounding healthy area. Sometimes loose teeth can be *splinted* (attached) to

Periodontal diseases

The illustrations below show two kinds of periodontal diseases. In *gingivitis,* calculus builds up between gums and teeth, causing the gums to become inflamed. In *periodontitis,* an inflammation gradually destroys the bony socket.



Gingivitis **Periodontitis**

nearby teeth that are still firm. But in many cases, the loose teeth must be removed and replaced by artificial ones.

Vincent's infection, also called *trench mouth,* is a painful infection of the gingivae. The gums become red and swollen and bleed easily. The mouth has an extremely bad odour, and the victim may develop a fever. To treat Vincent's infection, a dentist cleans the teeth and gums thoroughly and instructs the patient on mouth care. In most cases, the dentist also prescribes antibiotics to combat the infection.

Oral cancer is a disease that destroys the tissues of the mouth and may spread to other parts of the body. Scientists do not know for certain what causes oral cancer. But many factors can contribute to its development. For example, people who smoke or chew tobacco or drink excessive amounts of alcoholic beverages are exposing themselves to an increased risk of developing oral cancer.

Oral cancer may be painless and unnoticeable in its early stages. The first symptom may be a small sore in the mouth that does not heal. To test for cancer, a dentist removes some tissue from the sore. The tissue is examined under a microscope to determine if it is cancerous. Oral cancer may be treated with drugs, radiation, or surgery.

Teeth of animals

Many kinds of animals have teeth. However, birds, toads, turtles, and some types of insects and whales do not have teeth.

Cats, dogs, and most other mammals have *heterodont teeth*—that is, they have at least two types of teeth, which have different uses. For example, they may have incisors for biting into food and molars for crushing or grinding food.

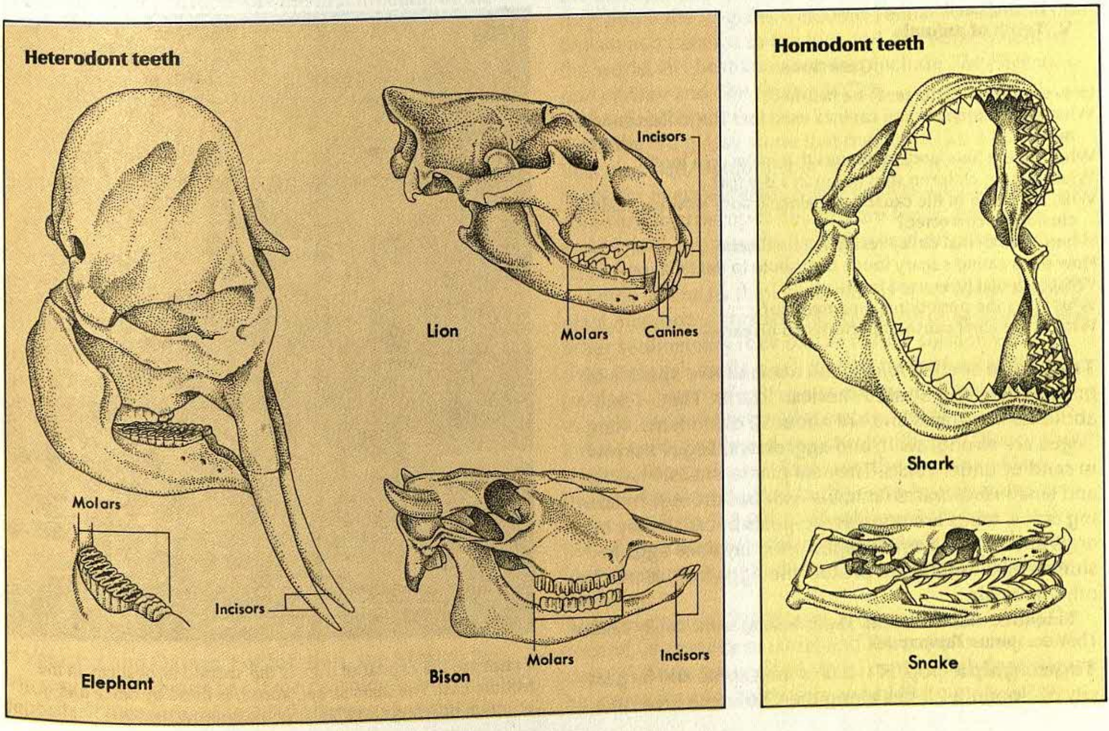
The teeth of various kinds of mammals differ in shape and size, depending chiefly on what the animals eat. For example, plant-eating mammals, such as elephants, giraffes, and sheep, have unusually broad, flat molars. They use the molars to chew and mash plants. Meat-eating mammals, such as lions, tigers, and wolves, have long, pointed canines. They use the canines to rip and tear the bodies of their prey.

Some mammals have teeth that grow continuously. The tusks of elephants are actually incisors that have become very long. The tusks have an open pulp, which enables them to keep growing. Beavers, rats, and other rodents also have incisor teeth that grow continuously. But most of the growth is worn down by continual use of the teeth, and so the teeth of these animals do not lengthen greatly.

Unlike most mammals, many fish and most reptiles have *homodont teeth*—that is, all their teeth are about the same size and shape and have only one use. In general, animals that have homodont teeth use their teeth to catch prey. Fish and reptiles lose and replace their teeth continuously.

Snakes have teeth that curve back toward the throat. Snakes swallow their prey whole and use their teeth to pull the prey back into the throat. In poisonous snakes, certain teeth have a canal or a groove, through which

Some animal teeth Animal teeth vary in size and shape. Most mammals have *heterodont teeth,* which consist of two or more types: incisors and canines for biting and tearing food, and molars for crushing it. Most reptiles and many fish have *homodont teeth,* a single type that generally is used to catch prey.



poison can be ejected. The poison comes from glands in the roof of the mouth.

Related articles in *World Book* include:

Human teeth

Abscess
Dental hygiene
Dentistry
Digestive system (From mouth to stomach)
Fluoridation
Fluorine
Mastication
Mouth
Orthodontics
Periodontitis
Races, Human
Saliva
Toothpaste and toothpowder
Trench mouth

Animal teeth

Animal (Jaws and teeth)
Beaver (Teeth)
Cat (The body of a cat)
Cattle (Teeth)
Dog (Body structure)
Elephant (Tusks and teeth)
Fish (Digestive system)
Hippopotamus (The body of a river hippopotamus)
Horse (Teeth)
Insect (Mouthparts)
Lion (The body of a lion)
Mammal (What mammals eat)
Pig (teeth)
Rodent
Ruminant
Shark (Teeth and scales)
Snake (Skeleton)
Whale (picture: Toothed whales)

Outline

I. Kinds of teeth
  A. Deciduous teeth
  B. Permanent teeth
II. Parts of a tooth
  A. Pulp
  B. Dentine
  C. Enamel
  D. Cementum
  E. Periodontal ligament
III. Care of the teeth and gums
  A. A good diet
  B. Cleaning the teeth
  C. Dental checkups
IV. Diseases and defects of the teeth
  A. Dental decay
  B. Malocclusion
  C. Periodontal diseases
  D. Oral cancer
V. Teeth of animals

Questions

How often should the teeth be brushed?
What are the incisors and canines used for? The molars and premolars?
What are the four kinds of tissues that make up a tooth?
When should children start going to a dentist?
What are some of the causes of malocclusion? How can malocclusion be corrected?
When does dental decay result in a toothache?
How does eating sugary foods contribute to dental decay?
What is dental floss used for?
What does the periodontal ligament do?
What is the chief cause of periodontal diseases?

Tegu, also spelled *teju,* is the name of two species of ground-dwelling South American lizards. They weigh about 2.5 kilograms and are about 90 centimetres long. Tegus are strong, swift, and aggressive. Tegus burrow in sand or under rocks. They eat plants, snails, insects, and small *vertebrates* (animals with backbones). In farming areas, tegus are considered pests because they eat eggs and chicks. Female tegus often lay their eggs inside termite mounds to protect the eggs from attack by other animals.

Scientific classification. Tegus belong to the family Teiidae. They are genus *Tupinambis.*

Tegucigalpa (pop. 571,400) is the capital and largest city of Honduras. It lies along the Choluteca River in a mountainous area of the south-central part of the country (see **Honduras** [map]).

The oldest parts of Tegucigalpa lie on the slopes of Mount Picacho, north of the Choluteca River. Neighbourhoods in this area are characterized by narrow brick streets and buildings that date from the 1800's. Since the mid-1900's, many office buildings, banks, and hotels have been built near the Plaza Morazán, also called Parque Central. Important buildings in central Tegucigalpa include the National Cathedral and the Presidential Palace. The National University lies outside of Tegucigalpa.

Manufacturing plants and government agencies employ many of Tegucigalpa's people. Chief products include textiles and processed foods and beverages. Tegucigalpa is not connected to the country's railway system, but it is served by an international airport.

Tegucigalpa was founded by Spaniards in 1578. In 1880, it replaced Comayagua as the capital. In 1938, Comayaguela, a city south of the Choluteca River, merged with Tegucigalpa. Since that time, Tegucigalpa has experienced rapid growth.

See also **Honduras** (picture).

Teheran (pop. 5,734,199), also spelled *Tehran,* is the capital of Iran and the second largest city in the Middle East. Only Cairo, the capital of Egypt, has more people. Teheran is Iran's cultural, economic, and political centre. It lies in northern Iran, at the foot of the Elburz Mountains. For location, see **Iran** (map).

The city. Teheran has many wide boulevards, which are lined with tall, modern buildings of Western-style architecture. The major business and government buildings and most of Teheran's fashionable shops are near the centre of the city. In the same area is an old busi-

Teheran, the capital of Iran, is the second largest city in the Middle East. The main street, *above,* is lined by office and government buildings and fashionable shops.

ness district where merchants sell fabrics, jewellery, and other handmade products at a bazaar that is hundreds of years old.

Most of Teheran's middle-class residents live in apartment buildings. Large numbers of poor people live in run-down apartments and houses in the southern part of Teheran. Many wealthy people live in large, beautiful houses north of the city.

Teheran has many parks and theatres. Its museums include the Archaeological and Ethnological museums and the Golestan Palace, which feature many treasures from Iran's past. The city has several universities, the largest of which is the University of Teheran.

Economy. The Iranian government employs many of Teheran's people. The city's industries include banking, construction, and petroleum processing. Factories in Teheran make bricks, cigarettes, textiles, and other products.

Buses and taxis provide public transportation in Teheran. An international airport lies west of the city.

History. People probably lived on the site of what is now Teheran at least 3,000 years ago. Teheran was a small town until the 1200's, when it began to grow. The city became the capital of Iran in 1788.

During the 1920's, many of Teheran's old buildings were torn down and replaced by new ones. Between 1960 and 1980, the population increased by about 4 million. This rapid growth caused such problems as a housing shortage, pollution, and traffic jams. Since the 1970's, a number of residential and office buildings have been built. During Iran's war with Iraq (1980-1988), Teheran suffered damage from bombing and rocket attacks. The city's economy, along with the national economy, experienced a severe setback.

See also **Iran** (picture: A boulevard in Teheran).

Teheran Conference was the first meeting of the main Allied leaders during World War II. These leaders, called the Big Three, were Prime Minister Winston Churchill of Great Britain, President Franklin Delano Roosevelt of the United States, and Premier Joseph Stalin of the Soviet Union. The meeting was also the first summit conference involving the heads of the Soviet Union and the United States. It took place from Nov. 28 to Dec. 1, 1943, in Teheran, Iran's capital.

The two main military decisions made at the conference were that the United States and Britain would launch an invasion of France in 1944 and that the Soviet Union would enter the war against Japan after Germany's defeat. The leaders also discussed plans for establishing a United Nations organization, for dividing and disarming Germany, and for moving Poland's borders westward after the war. The Polish-Soviet border would be redrawn to add territory to the Soviet Union that had been part of Russia before World War I began in 1914. The cooperative spirit of the Teheran Conference paved the way for later agreements among the Allied war leaders at the Yalta Conference in 1945.

Tehran. See Teheran.

Tehuantepec, Isthmus of, forms the narrowest part of Mexico. It lies between the Bay of Campeche and the Gulf of Tehuantepec, and includes parts of the states of Veracruz and Oaxaca. For location, see **Mexico** (terrain map). The isthmus has large petroleum and sulphur deposits. It measures about 210 kilometres wide at its narrowest point. Most of the land is tropical lowland. Foothills of the Sierra Madre mountains rise in the south.

Teifi is a river in Dyfed, in southwest Wales. The Teifi rises at the Teifi Pools, near Strata Florida, and flows through Lampeter, Newcastle Emlyn, and Cardigan to St. George's Channel.

Teignbridge (pop. 107,100) is a local government district in south Devon, England. The district includes the seaside resorts of Dawlish and Teignmouth and, inland, part of the Dartmoor National Park. Tourism and farming are the main industries. Newton Abbot, the district's administrative centre, is a market town. Buckfastleigh has a woollen industry. See also **Devon.**

Teilhard de Chardin, Pierre (1881-1955), was a French *palaeontologist* (expert in fossils). He helped discover Peking man, an early type of human being. Teilhard's greatest fame, however, rests on a theory that claims to unify cosmic evolution and Christianity.

Teilhard entered the Jesuit order in 1899 and was ordained a priest in 1911. He lectured for a time at the Catholic Institute in Paris. His theory of evolution in relation to the Catholic doctrine of original sin in his lectures was considered unorthodox. As a result, church authorities forbade him to continue teaching in Paris. Teilhard then lived in China from 1923 to 1946, where he was a consultant to the United States National Geological Survey. He began his fossil research in 1923. He wrote extensively in China. However, most of Teilhard's writings were controversial, and so they were not published until after his death.

According to Teilhard, "Evolution is a general condition to which all theories, all hypotheses, all systems must bow and which they must satisfy if they are to be thinkable and true." He placed humanity at the centre of the universe and Christianity at the centre of human history. Some theologians welcome Teilhard's extreme optimism as a balance to the fear and discouragement in the world. His best-known works include *The Phenomenon of Man* and *The Divine Milieu.*

Teju. See Tegu.

Tektite is a glassy stone that may look like a teardrop, ball, disc, rod, dumbbell, or button. A few tektites are blocklike in appearance. Many tektites are nut-sized, but some are microscopic. Tektites are black, green, or amber, and they usually have grooved or pitted surfaces.

Some scientists think that tektites were formed when giant meteorites crashed into deposits of sandstone and other sedimentary rock on the earth's surface. Fragments of such rocks were melted by the heat of the impact and scattered over great distances. They solidified in flight and fell back to the earth as tektites. Other scientists have developed an entirely different theory about tektites. They believe tektites are the remains of lava masses that were hurled to the earth by volcanoes on the moon from 750,000 to 35 million years ago. The liquefied rock materials that were ejected during the violent eruptions solidified into stony glass on the way to the earth.

Tel Aviv (pop. 325,700; met. area pop. 1,350,000) is the second largest city of Israel and the nation's chief commercial, financial, and industrial centre. Only Jerusalem has more people. Tel Aviv is one of the most modern

Tel Aviv, Israel's chief commercial, financial, and industrial centre, lies on the eastern shore of the Mediterranean Sea. Yachts dock near modern buildings of the city, *above.*

cities in the Middle East. It lies on the eastern shore of the Mediterranean Sea. For the location of Tel Aviv, see **Israel** (political map).

The heart of Tel Aviv is a major roundabout in the centre of the city called Dizengoff Circle. Fashionable shops and pavement cafes line the nearby streets. The 37-storey Shalom Tower stands in the centre of the city's financial district, several streets south of Dizengoff Circle. It is the tallest building in Israel. The southwestern section of the city was formerly a separate town called *Jaffa* (*Yafo* in Hebrew). Jaffa, an ancient port area that dates back to Biblical times, has many historic sites that have been restored by archaeologists. Jaffa also has many art galleries, cafes, restaurants, and nightclubs. Most people in Tel Aviv live in apartment buildings.

Cultural attractions in Tel Aviv include the Museum Haaretz and the Tel Aviv Museum. Tel Aviv University is one of the city's several institutions of higher learning. Bar Ilan University is in Ramat Gan, a suburb of the city.

Tel Aviv is the centre of Israel's chief manufacturing district. About half the nation's business companies are in the area. Their products include building materials, chemicals, clothing, electronic equipment, machine tools, and processed foods. The city is also the nation's leading centre for banking, publishing, and trade.

In 1909, Jewish immigrants from Europe founded Tel Aviv northeast of Jaffa. Tel Aviv was administered as part of Jaffa at first, but it became a separate town in 1921. Tel Aviv grew rapidly as Jewish immigrants poured in, mainly from Europe. It became Israel's first capital when the nation was established in 1948. The capital was moved to Jerusalem in 1949, but the Israeli Ministry of Defence and many foreign embassies remained in Tel Aviv. Most government departments maintain offices in Tel Aviv. In 1950, Tel Aviv and Jaffa merged to form the city of Tel Aviv-Yafo. Tel Aviv-Yafo remains the official name, but the city is almost always called Tel Aviv.

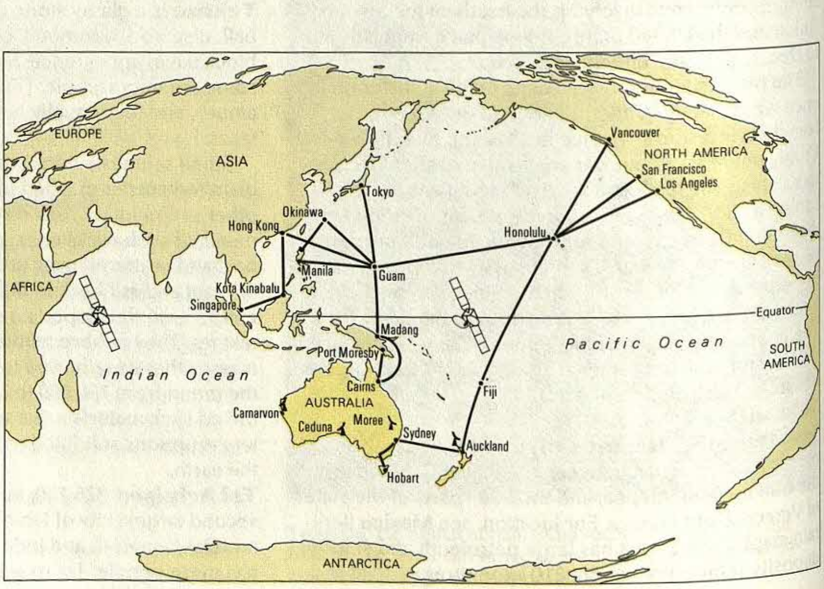
Tel Aviv continued to grow rapidly in the 1950's and early 1960's. Its population reached about 392,100 in 1965 and then began to decline, but the suburban population continued to rise. The rapid growth of the Tel Aviv area resulted in such problems as air pollution, slums, and traffic jams. During the Persian Gulf War of 1991, Iraq fired about 25 missiles toward Tel Aviv. Several missiles and falling debris struck residential areas in or around Tel Aviv. Two people were killed, and about 7,500 apartments were damaged.

See also **Israel** (picture); **Jaffa.**

Telecommunication is the transmission and reception of messages over long distances. Visual signalling with flags, lamps, or smoke was the earliest form of telecommunication. Today, the term refers to a wide variety of electrical and electronic communication systems used throughout the world. Modern telecommunication systems send and receive sound, printed materials, and visual images in a fraction of a second.

Common telecommunication systems include telephones, television sets, and radios. Other kinds of systems are used chiefly in industry. These systems can

Overseas telecommunications are carried by satellites and submarine cables. The Anzcan cable links Sydney with Canada by way of Norfolk Island, Fiji, and Hawaii. It also has a spur to New Zealand. The Seacom cable links Cairns, Australia with Hong Kong by way of Guam.



transmit such information as airline reservations, banking transactions, and stock market reports. Newspapers rely on teleprinter and telephoto equipment to obtain news stories and photographs from all parts of the world. Communication between space stations and the earth also has been established through telecommunication.

Most telecommunication systems transmit messages by wire, radio, or satellite. Many telegraph messages and telephone conversations, especially local calls, travel over wires that are laid underground in cables. Cables on the sea floor handle such communications that travel overseas. Television and radio broadcasts are sent through the air by radio waves. Radio waves called *microwaves* transmit television signals over extremely long distances. Microwaves are also used in most long-distance telephone communication. Communications satellites orbiting the earth transmit telephone, television, and other communications signals throughout the world.

There are two methods of telecommunication transmission, *analogue transmission* and *digital transmission.* Analogue transmission uses signals that are exact reproductions of the sound or picture being transmitted. For example, an analogue telephone system transmits an electric current that copies the pattern of sound waves of the speaker's voice. This current travels over wire and is converted back to sound waves in the telephone receiver.

In digital transmission, the signals are converted into a code. In most cases, the code has two elements, such as the dot-dash of Morse code or the on-off flashing of a light. In one type of digital telephone system, the coded signals are transmitted by a rapidly flashing beam of light and are decoded in the receiver. A device called a *laser* produces the light, which travels through thin strands of glass called *optical fibres.*

When transmitting a telephone conversation, the light in the system flashes on and off about 45 million times per second. This high rate enables two optical fibres to carry about 6,000 conversations at the same time. It would take 250 copper wires to handle as many conversations. Digital transmission also involves less noise and distortion than an analogue system. Many telecommunication systems are being converted from analogue to digital transmission.

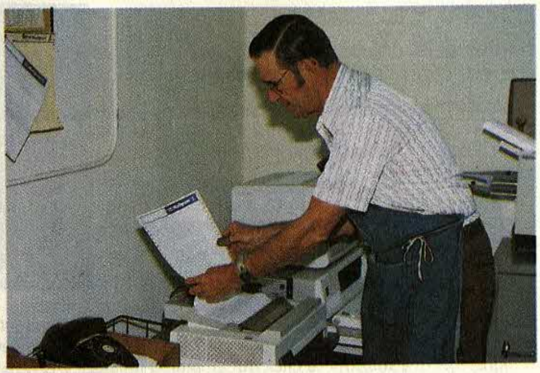
Related articles in *World Book* include:

Cable
Coaxial cable
Communication (The development of modern communication; pictures)
Electromagnetic waves
Electronics
Facsimile
Fibre optics
International Telecommunication Union
Microwave
Radio
Satellite, Artificial (Communications satellites)
Telegraph
Telemetry
Telephone
Telephoto
Teletypesetter
Teleprinter
Television

Telegram. See Telegraph.

Telegraph was the first device to send messages by electricity. At one time, most telegraph messages were sent by tapping out a special code for each letter of the message with a telegraph key. The telegraph changed the dots and dashes of this code, which became known as the *Morse code,* into electrical impulses and transmitted them over telegraph wires.

Today, most long-distance electric or electronic communication signals are transmitted by such means as communications satellites, broadcasting aerials, and coaxial and fibre-optic cables. The telegraph is the common ancestor of these devices, but it is now rarely used where more advanced technology is available. However, the term *telegram* still applies to several kinds of communication in which an electronically transmitted message is delivered to the receiver in paper form.



A telegram is transmitted over wires to a telegraph office close to the receiver. There the message is removed from the telegraph's printer, *above,* and delivered to the receiver.

Sending a telegram

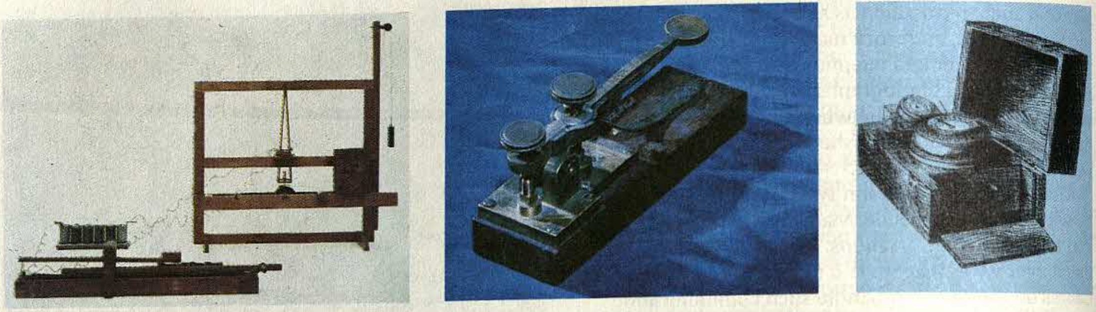
In countries where a telegraph service is available, a person may send a telegram by telephoning the message to a special telephone bureau of the telegraph company. A person also may go to a public telegraph office or telegraphic agent and write the message on a special form.

A message telephoned to the telephone bureau of a telegraph company is recorded by an operator using a *visual display unit,* a device that reproduces the message on a screen. The operator depresses a key to send the complete message to a message-switching computer, which routes the message to the circuit serving the point of destination. A message submitted at a message office may also be transmitted to the computer by a *teleprinter.* A teleprinter has a keyboard similar to that of a typewriter, and the message is sent by typing it. After reaching its destination, a telegram may be telephoned or delivered in person to the receiver.

Kinds of telegrams

Telegraph messages that travel over land are called *telegrams* or *wires.* Such messages are called *cablegrams* or *cables* if they go by underwater cables. Ordinary telegrams are transmitted and delivered within a few hours. A fixed rate is charged for a minimum number of words, and an extra fee for each additional word. In addition to ordinary telegrams, there are several special types, including *mailgrams.*

Mailgrams, also called telemessages and other names, combine the facilities of telegraph and postal delivery to convey messages. The sender phones the message to the telephone bureau of the telegraph company, and the message is electronically transmitted to the post office nearest the receiver. It is delivered with the next day's post.



The first telegraphs. Samuel Morse's first telegraph, *left,* patented in 1837, had an electromagnet that caused a pen to make V-shaped marks on paper. Later, he developed the Morse code and a telegraph with a sounder to click out incoming messages, *centre.* In 1837, two English inventors produced a telegraph, *right,* with needles that pointed to letters to spell out the message.

Development of the telegraph

Before electric telegraphy, most messages that travelled long distances were entrusted to messengers, who memorized them or carried them in writing. Such messages could usually be delivered no faster than the fastest horse. An exception was the *semaphore,* or *visual telegraph* system, in which a sequence of fire beacons or other markers signalled from point to point. In the 1790's, Claude Chappe, a French inventor, established a system of visual telegraph towers that relayed messages across France. However, visual telegraphs did not work well at night or in bad weather. Even in good weather, they could transmit only a small amount of information.

The electric telegraph makes use of the relationship between magnetism and electricity. During the 1790's, the Italian scientist Alessandro Volta invented an electrochemical cell that made a steady source of electric current available. In 1820, the Danish physicist Hans Christian Oersted discovered that an electric current will cause a magnetized needle to move. This principle is the basis of the telegraph, in which a current is varied systematically according to a code. The British electrician William Sturgeon invented the electromagnet in 1825. Three men used these discoveries to develop telegraphs and commercial applications for them. They were the physicists William F. Cooke and Charles Wheatstone, working together in Great Britain, and American inventor and painter Samuel F. B. Morse.

The Cooke-Wheatstone telegraph. In 1837, Cooke and Wheatstone patented a telegraph that worked by electromagnetism. Their receiving instrument had five or six magnetic needles mounted vertically on a dial on which the letters of the alphabet were printed. A separate wire and a coil that served as an electromagnet controlled each needle. When an electric current passed through one of these wires, it produced a magnetic field in the coil, causing the needle to move. Letters were signalled by pointing two needles toward the letter at the same time. In principle, the Cooke-Wheatstone telegraph was a miniature electric semaphore system. A single-needle version was patented in 1845 and was used in Great Britain until 1870.

The Morse telegraph was first publicly demonstrated in 1837. The sending device was a switch, called a *key,* that completed a circuit and allowed current to flow to a receiving *sounder.* In the sounder, the current caused an electromagnet to attract an iron bar, called an *armature.* The armature struck the electromagnet, making a clicking noise in Morse code, a dot-dash code developed by Morse. With each click, a pointed instrument attached to the armature also *embossed* (marked) the code on a strip of paper, creating a record of the transmission. When the key was released, the circuit was broken and no current flowed. This caused the electromagnet in the sounder to lose its magnetism, and a spring pulled the bar back to its original position. Morse also developed a relay device to lengthen the distance over which messages could be sent. Morse patented his telegraph in 1840.

In 1843, Morse received 30,000 U.S. dollars from Congress to build an experimental telegraph line from Washington, D.C., to Baltimore, Maryland, U.S.A. When the Whig Party met in Baltimore in May 1844 to nominate a candidate for the presidency, the telegraph line was within 24 kilometres of Baltimore. News of the nomination of former Senator Henry Clay was rushed to the end of the telegraph line and transmitted instantly to Washington. An hour and a half later, the train from Baltimore arrived with verification. However, Clay had been most likely to win the nomination, and doubters were not impressed. When news of the vice presidential nomination also arrived ahead of the train, even doubters were converted. On May 24, 1844, Morse sat at a sending device in the Supreme Court chamber of the Capitol and tapped out the first official telegraph message, "What hath God wrought!"

Early expansion. In the United States, the Morse telegraph was successful for a number of reasons, including its simple operation and its relatively low cost. By 1851, the country had more than 50 telegraph companies. Most telegraph business was controlled by the Magnetic Telegraph Company, which held the Morse patents.

The Magnetic proprietors wanted to build a system of lines linking the main commercial routes of the nation. They assigned parts of this system to various partners. However, bitter arguments and competition arose, and some partners left to build rival systems. Rate-cutting and questionable investment practices were common. Lines and instruments were often built carelessly and with inferior materials. Several companies went bankrupt as a result of such problems as fierce competition, lawsuits, and insufficient income. In the public's view, the telegraph did not work reliably. Messages often did not reach their destination, and rates were high and unpredictable.

Telegraphy and the railway. Despite the difficulties, some businesses found the telegraph useful. For example, newspapers printed columns of "telegraph news." Stockbrokers used the telegraph to move important information rapidly. But the telegraph's most valuable and constant partner was the railway.

Western Union Telegraph Company was one of the first telegraph companies to gain benefits from contracts with railways. In these contracts, the railway agreed to lay telegraph lines along railway rights of way. The railway also agreed to provide office space in depots for telegraphers employed by both the railway and the telegraph company and free transportation for people who repaired the telegraph lines. In return, Western Union agreed to transmit messages relating to railway business free of charge, and to give priority to messages concerning the movement of trains.

The telegraph helped coordinate train schedules and increase safety. Trains could be moved more quickly using a common time standard transmitted to every station at the same instant. The location of any train could be known with certainty. The telegraph made the railway a safe and efficient national transportation network. The railway offered the telegraph company a monopoly of protected routes.

Western Union. During the 1850's, competition between telegraph companies gave way to profitable mergers as the telegraph pushed west. Short, disconnected, broken-down lines were rebuilt and combined into extensive networks. By the 1860's, central telegraph offices existed in every major city.

By the beginning of the American Civil War in 1861, there were two major telegraph companies in the United States: (1) Western Union, whose lines ran east and west, and (2) American Telegraph, whose lines ran north and south along the East Coast. The Civil War destroyed the north-south lines of American Telegraph and strengthened the east-west lines of Western Union, which connected states loyal to the Union. After the war, Western Union absorbed its only significant remaining rivals. Western Union was both the first industrial monopoly in the United States and the nation's largest corporation. It became the most successful of all the telegraph companies. See **Western Union.**

Across the Atlantic. Western Union had completed a transcontinental link by 1861. In 1866, a permanent transatlantic link was achieved. A cable 3,200 kilometres long was laid from the *Great Eastern,* the largest ship of its day. American businessman Cyrus W. Field and his British and American associates were largely responsible for the success. The British physicist Lord Kelvin offered essential scientific and technical advice. See **Cable** (The Atlantic telegraph cable).

Faster and better service. Improvements in telegraphy increased the message capacity of single wires and the speed of message handling and transmission. The *duplex system,* which could send two messages over one wire at the same time, one in each direction, began operating in the United States in 1872. Two years later, American inventor Thomas A. Edison developed a *quadruplex system,* which handled four messages at the same time. In 1875, Émile Baudot, a French telegrapher, developed a *multiplex system* that could handle five at once. In 1915, Western Union began using a system capable of multiplexing eight messages at a time.

Devices to send and receive messages in printed form instead of Morse code were also developed in the late 1800's and early 1900's. At the same time, methods of sending messages by means of a paper tape punched with holes were introduced. Multiplex systems used a punched-tape method. Teleprinters, which can send electrical impulses directly over telegraph lines to similar printers at the receiving end, were generally adopted in the late 1920's. In 1925, a telephotograph and facsimile telegraph system began operating in the United States. These systems can send and receive telegrams in picture form (see **Facsimile; Telephoto**). *Telex* and *TWX,* which are interconnected two-way dial teleprinter services, were introduced during the 1930's.

Effects of telegraphy. New management methods worked out in the partnership of wire and rail were applied to other businesses in the 1800's. With rapid telegraphic communication, it was possible to increase both the number of operating units in a single company and their distance from headquarters. Efficient supervision by means of cheap, fast long-distance telegraphy helped change the structure of business. Large, corporate structures began to replace small, separate businesses. The union of wire and rail also made possible the efficient organization of the entire United States as one national market. Information about products for sale could move quickly between producer and consumer.

Telegraphy also transformed the press. When the United States declared war on Mexico in 1846, the front was seven days away from the East Coast by the fastest government mails. In order to obtain the latest news quickly, six newspapers formed the New York Associated Press. This news service, which later became the Associated Press, used the telegraph to collect the news and sell it to other newspapers (see **Associated Press; News service**).

The telegraph today. For many years, the telegraph was a vital part of commerce, government, and the military. It greatly influenced the machines that came after it. The original backers of the American scientist Alexander Graham Bell believed the telephone he invented in 1876 was a talking telegraph that could compete with the Western Union monopoly. Radio, patented by the Italian inventor Guglielmo Marconi in 1896, was called *wireless telegraphy.* The distribution of telegraphic news from a central wire service to other newspapers was the original model for national network broadcasting of radio and television to associated stations.

The introduction of the telephone took away most of the short-distance communication business of the telegraph. The arrival of long-distance telephone communication threatened to eliminate the remaining telegraph business. Today, the telegraph has been largely replaced by such communications machines as computers and communications satellites. These machines are faster than the telegraph and can process many kinds of information.

Related articles. See the *Communication* section of the various country articles. Other related articles in ***World Book*** include:

Biographies

Cornell, Ezra
Edison, Thomas A.
Grey, Elisha
Henry, Joseph
Kelvin, Lord
Morse, Samuel F. B.
Pupin, Michael I.
Wheatstone, Sir Charles

Other related articles

Associated Press
Cable
Common carrier
Communication
Facsimile
International Telecommunication Union
Morse code
News service
Radio (History)
Stock ticker
Telephone
Telephoto
Teleprinter
Western Union

Telegraph plant is a herb about 1.2 metres high. It is native to tropical Asia, and grows in greenhouses in many parts of the world. If the plant, or especially its leaves, is touched, the leaves quickly droop downward, like the arms of a railway semaphore signal. The plant received its common name from these leaf movements. It bears small purple flowers. The seed pods are jointed and can be separated easily.

Scientific classification. The telegraph plant belongs to the pea family, Leguminosae (Fabaceae). It is *Desmodium gyrans.*

Telegraph plant

Telemann, Georg Philipp (1681-1767), was perhaps the most famous German composer of his day. Telemann wrote thousands of compositions in the popular forms of the 1700's. He wrote more than 1,000 cantatas as well as operas, concertos, oratorios, and chamber music. His music forms an important link between the baroque style of Johann Sebastian Bach and the classical style of Joseph Haydn.

Telemann's works show an understanding of melody and harmony with a strong sense of musical form. He was concerned that his music would be suitable for performance by amateurs. His best-known works include the operas *Der geduldige Socrates* (1721) and *Pimpinone* (1725), the cantata cycle *Harmonischer Gottes-Dienst* (1725-1726), and a three-part collection of orchestral pieces called *Musique de Table* (1733).

Telemann was born in Magdeburg, Germany, and studied in Leipzig. From 1712 to 1721, he was director of music in Frankfurt am Main. In 1721, he became the music director for the five main churches in Hamburg, where he spent the rest of his life. From 1722 to 1738, he served as director of the Hamburg Opera. Telemann wrote two volumes of autobiography, published in 1718 and 1739.

Georg Telemann

Telemetry means *measuring at a distance.* Scientists and engineers use telemetry in many ways. Scientists send weather balloons as high as 30 or 50 kilometres into the air to measure the air temperature, pressure, and humidity above the earth. Radio transmitters attached to the balloons relay this information back to the earth.

Artificial satellites also are used to measure conditions in the atmosphere and the oceans. They transmit this information back to receiving stations on the earth. The receiving stations use computers to analyse the mass of data.

Telemetry also helps people explore outer space. Rockets and spacecraft send information about their own performance and conditions in outer space to scientists and engineers on the earth. On manned flights, telemetry systems provide data on astronauts' physical condition by reporting their pulse rate, blood pressure, and temperature. To save space and weight, special miniature equipment is used in spacecraft.

A telemetry system consists of a measuring instrument, a transmitter, and a receiving station. For example, a telemetry system that records temperatures at remote locations uses an electrical thermometer as the measuring instrument. Signals produced by the thermometer are transmitted by radio or by wire to a receiving station. Instruments at the receiving station record the signals on magnetic tape and convert them into meter readings and graphs.

Teleology. See **Mechanist philosophy.**

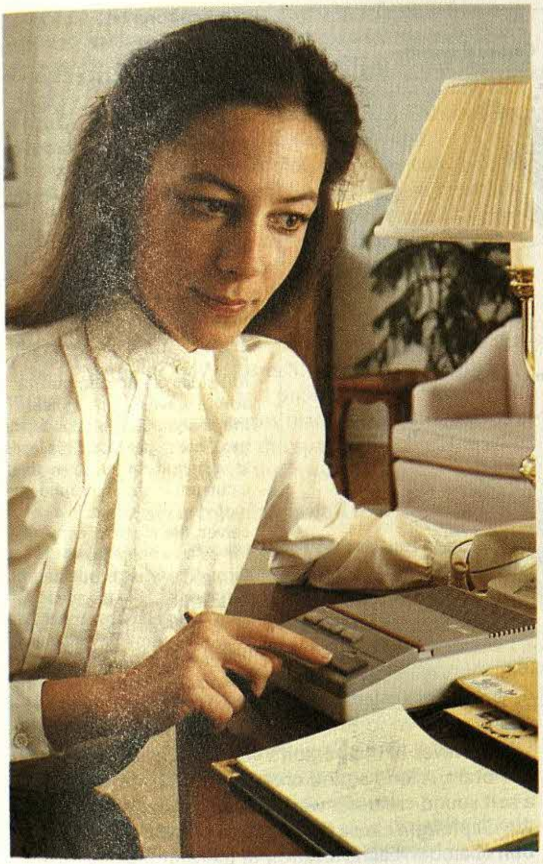
Telepathy is the communication of thoughts, feelings, or knowledge from one person to another without the use of any of the traditionally accepted senses of hearing, sight, smell, taste, or touch. Telepathy is sometimes called *mind reading* or *thought transference.* An example of telepathy would be if one person thought of something specific and another person stated or wrote the thought correctly. To be telepathic, however, the performance would have to be repeated and could not be explained in any other way.

Telepathy is part of the subject matter of parapsychology and is studied by scientists called *parapsychologists.* Parapsychologists believe that neither distance nor time affects telepathy. Thus, a person's thoughts might be received by another person who is far away. Parapsychologists also believe that a person may know in advance the thoughts, feelings, or knowledge that another person will have at a later time. If true, this would be an example of *precognitive telepathy.*

Telepathy is considered a major form of *extrasensory perception (ESP),* an awareness of something without the use of the known senses. Telepathy is under scientific investigation. Its existence is still an open question, but many scientists doubt its reality.

In a typical experiment to test for telepathy, one person looks at a series of cards, one at a time, and concentrates on the image on each card. A second person, isolated from the first, tries to determine what each image is. The experimenter carries out a statistical analysis of the results. This can show whether the second person could have achieved the same rate of success purely by chance.

See also **Extrasensory perception; Clairvoyance; Mind reading; Parapsychology; Psychical research.**



The telephone is a valuable means of communication. A telephone answering machine, *above left,* records messages from callers. A facsimile machine, *top right,* lets people send written words and pictures over telephone lines. A portable phone, *bottom right,* can be used outdoors.

Telephone

Telephone is an instrument that sends and receives voice messages, usually by means of electric current. It is one of our most valuable means of communication. In just a few seconds, you can telephone a person across the street, in another part of the country, or on another continent. The word *telephone* comes from two Greek words meaning *far* and *sound.*

In its most basic form, a telephone enables people to talk with one another at distances beyond the range of the human voice. More sophisticated telephones can send and receive not only voice messages, but also written words, drawings, photographs, and even video images. In addition, telephones can send information from one computer to another.

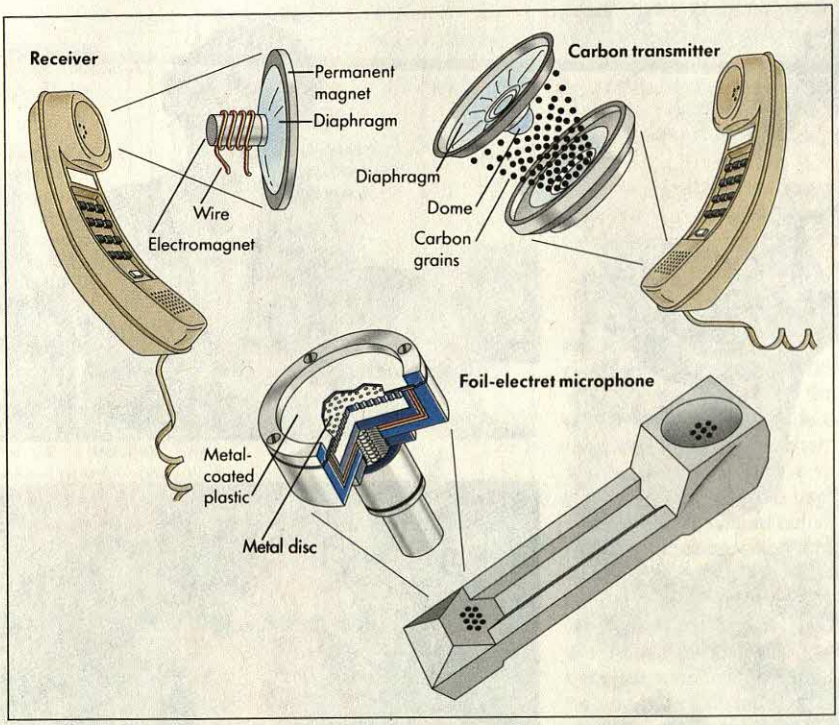
Telephones in people's homes are just one part of a vast, complex *telephone network.* The network also includes large computers, tremendous lengths of copper wire and hair-thin strands of glass, cables buried in the ground and laid along the bottom of the oceans, radio transmitters and receivers, and artificial satellites orbiting far above the earth.

Most telephones connect with the telephone network by means of wires that run through the walls of homes and other buildings. A small clip connects each telephone to the wiring. Other phones are installed in cars or carried in a bag or pocket. Such phones connect with the network by radio.

Alexander Graham Bell invented the telephone in 1876. Today, hundreds of millions of telephones serve people all over the world.

How a telephone works

The part of a telephone that a person picks up to make a phone call is the *handset.* It has an earpiece and a mouthpiece. Before making a call, the person listens in the earpiece for a *dial tone.* This sound indicates that a telephone line is available to handle the call. The caller then enters a *telephone number,* a sequence of numbers (or letters and numerals) that specifies the telephone being called. The telephone network uses the numbers to establish a connection between the two phones. When the caller speaks into the mouthpiece, the telephone converts the sound waves of the person's voice into an electric current. The telephone network uses various devices to create an almost perfect duplicate of the current in the telephone of the person being spoken to. That telephone converts the current into



A telephone handset includes a transmitter or microphone, which produces an electric "copy" of the user's voice, and a receiver, which duplicates the voice of the person on the other end of the line. In a carbon transmitter, the sound wave of the user's voice makes a diaphragm vibrate. The vibrations cause a metal dome to exert pressure on carbon grains. Electric current flows through the grains with a strength related to this pressure, "copying" the voice. In a foil-electret microphone, the sound waves cause a sheet of metal-coated plastic to vibrate next to a metal disc. This leads to variations in the strength of a current in the microphone, "copying" the voice. In a receiver, the electric "copy" of the caller's voice flows through a wire, producing variations in the magnetic field of an electromagnet. As a result, a permanent magnet vibrates a diaphragm, generating sounds like those of the voice.

sound waves very much like those of the caller's voice.

A telephone has three main parts: (1) a dialling mechanism, (2) a transmitter, and (3) a receiver.

The dialling mechanism enables a caller to enter telephone numbers. The dialling mechanism may be built into the handset, between the earpiece and the mouthpiece. Or it may be part of a separate base unit that connects by cord to the handset.

In many modern telephones, the dialling mechanism consists of a set of buttons or keys called a *keypad.* When pressed, each key generates either a certain number of electric pulses or a pair of accurately controlled tones. Computers in the telephone network use the sequence of pulses or tones to direct the call.

The dialling mechanism on some telephones consists of a disc called a *rotary dial.* The dial has finger holes that correspond to the digits 0 to 9. A caller enters a telephone number by rotating and releasing the dial. This action generates electric pulses.

The transmitter, also called the *microphone,* converts the sound waves of a person's voice into an electric current and sends this current further into the telephone network. The transmitter is built into the handset, behind the mouthpiece. There are two main kinds of telephone transmitters—(1) the carbon transmitter and (2) the foil-electret condenser microphone.

The carbon transmitter has two main parts—a *diaphragm* and a *carbon chamber.* The diaphragm is a thin, round piece of aluminium. The carbon chamber lies behind the diaphragm, between two electric terminals. It contains many tiny grains of carbon. Low-voltage electric current travels through the carbon grains. A small, gold-plated brass dome located on the underside of the diaphragm also rests in the carbon chamber.

When a person speaks into the mouthpiece, the sound waves of the person's voice cause the diaphragm to vibrate. A loud sound creates a strong vibration, and a soft sound creates a weak vibration. The motions of the diaphragm cause the dome to vibrate within the carbon chamber. Each vibration of the dome compresses the carbon grains. A small vibration places light pressure on the grains, while a large vibration squeezes them tightly together. The greater the compression of the grains, the more easily electric current passes through them. So the louder the sound, the greater the flow of electric current.

The foil-electret microphone has a circular diaphragm consisting of a thin sheet of electrically charged plastic with a metal coating on one side. This diaphragm, called a *foil electret,* is stretched over a hollow metal disc called a *backplate.* The metal coating on the diaphragm faces away from the backplate.

The diaphragm touches the backplate only in certain areas. In other areas, the diaphragm and the backplate are separated by air pockets. The diaphragm can vibrate in these pockets when hit by sound waves.

The electric charge carried by the diaphragm sets up an electric field between the diaphragm and the backplate. The strength of this field depends in part on the distance between the diaphragm and the backplate.

When a person speaks into the mouthpiece, sound waves hit the diaphragm. The resulting vibrations change the distance between the diaphragm and the backplate—and thus the strength of the electric field. These variations in field strength trigger corresponding variations in an electric current.

The receiver converts the electric current coming through the telephone line into a duplicate of the speaker's voice. The receiver is built into the handset, behind the earpiece.

In a receiver, an iron diaphragm in a flexible frame is surrounded by a ring-shaped *permanent magnet.* The permanent magnet exerts a constant pull on the diaphragm. Another magnet, called an *electromagnet,* is attached to the other side of the diaphragm. This magnet is made of metal with a coil of wire around it.

When the electric current flows into the coil, the electromagnet becomes magnetized. The current moves in two directions. When it moves in one direction, the resulting magnetism adds to the pull of the permanent magnet and causes it to attract the diaphragm more strongly. When the current moves in the other direction, the resulting magnetism opposes that of the permanent magnet and reduces its pull on the diaphragm. The variation in magnetic pull causes the diaphragm to vibrate at the same rate. It pulls and pushes the air in front of it, producing pressure changes that create sound waves almost the same as those of the speaker's voice. The listener hears a duplicate of the speaker's voice.

How a telephone call travels

Telephone lines crisscross a country and connect millions of telephones in a vast network. Most telephone lines consist of copper wires. Many long-distance calls travel by radio systems. In most countries, almost all telephone wires are bound together in cables. Some cables have more than 4,000 wires.

Lines for local calls. When you make a local telephone call, the call travels over wires or by radio to a local exchange. There, switching equipment connects your telephone to the phone you are calling. The switching process may be automatic or manual.

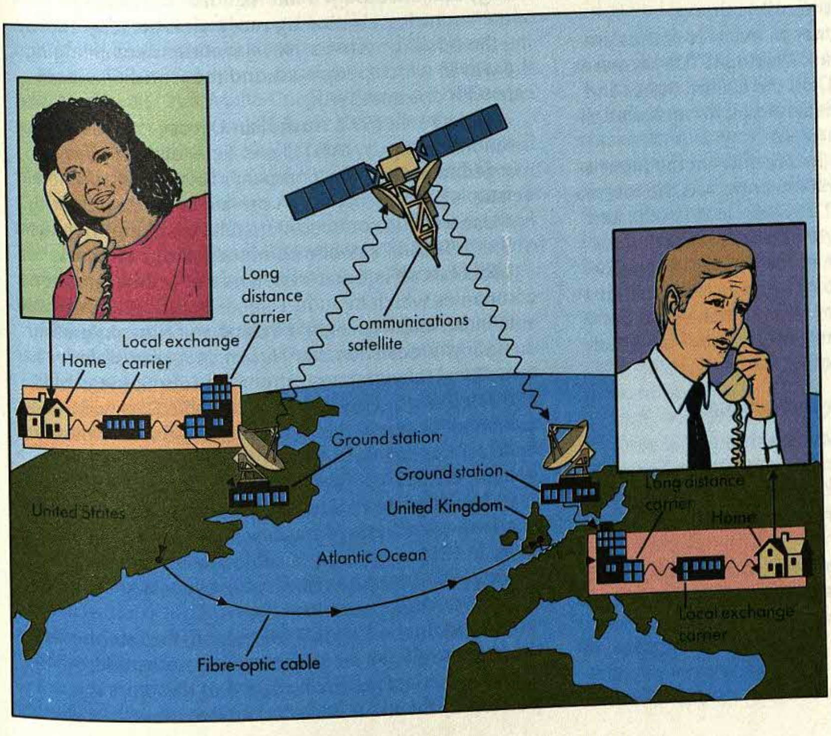
Long-distance lines. The same kind of cables used for local calls could be used for long-distance calls. At great distances, however, the electric signals in the wire would become too weak. To overcome this problem, long-distance lines are equipped with *repeaters* (amplifiers) that strengthen the electric current through such electronic devices as transistors.

A long-distance call would be very expensive if only one call could be transmitted on a pair of wires at a time. Engineers have developed ways to send many telephone messages on the same pair of wires. A process called *carrier transmission* enables two pairs of wires to carry as many as 96 conversations at the same time. Each electric current carrying a conversation travels at a different *frequency* (rate of vibration). Electronic filters at each end of the line sort out the conversations.

Coaxial cables make it possible to send even more messages along the same route. A coaxial cable consists of up to 22 *coaxial conductors*—copper tubes about as thick as a pencil—that work on the carrier transmission principle. A pair of tubes can carry up to 13,200 telephone conversations. See **Coaxial cable.**

In the late 1970's, telephone companies began replacing coaxial cables with fibre-optic cables. A fibre-optic system uses bundles of extremely fine glass fibres to carry calls on a laser beam. The first long-distance fibre-optic cable was completed in 1983. Signals sent over fibre-optic cables need less amplification than signals sent over copper cables of equal length. Fibre-optic cables can also carry more information than copper cables, making them especially popular for heavily used long-distance telephone lines. See **Fibre optics.**

Both wires and cables must be strung on poles or placed underground. To reduce the cost of long-distance phoning, telephone companies use radio relay systems that send and receive telephone calls by radio waves. Radio relay systems use superhigh frequency radio waves called *microwaves* (see **Microwave**). Micro-



An intercontinental call from the United States to the United Kingdom travels through the sky or under the ocean. Telephone signals pass from the caller's home phone to one or more local telephone offices called *local exchange carriers,* which pass the signals to a *long-distance carrier.* This office directs the call in one of two ways. In one method, the signals go to a *ground station,* which beams them to a communications satellite. The satellite relays the signals to a UK ground station. In the other transmission method, the long-distance carrier routes the signals to a fibre-optic cable that runs beneath the Atlantic Ocean. With both methods, the signals reach a UK long-distance carrier. The call then passes through one or more local exchange carriers and finally reaches its intended destination.

waves travel mostly in straight paths. They are concentrated in a narrow beam like that of a searchlight. They are focused from one relay station to another. The stations are about 50 kilometres apart. Each relay station has dish aerials to transmit and receive microwaves. A microwave route can carry almost 36,000 telephone conversations.

The *over-the-horizon* radio relay system sends microwaves beyond the horizon. It uses powerful relay stations up to about 320 kilometres apart. The stations send microwaves aimed at the horizon by means of larger dish aerials. Much microwave energy is lost in space. But enough scatters downward and carries the radio signals to the next station, much as the headlights of a car shine over a hill without being directly seen. Over-the-horizon systems operate between, for example, Japan and Korea in the Pacific, and Tortola and Trinidad in the Caribbean. To direct microwave signals across oceans, the network uses artificial satellites.

Telephone services

A person can make three kinds of telephone calls—*local, long distance,* and *overseas.*

Local calls. In some countries a customer can make an unlimited or set number of local calls for a fixed charge. Elsewhere, individual calls are charged at a rate that depends on the distance called, the number of minutes talked, and the time and the day of the call.

Long-distance calls, sometimes called *trunk calls,* include *station-to-station calls* and *person-to-person calls.* In a station-to-station call, the charge begins as soon as the telephone is answered. In a person-to-person call, the charge does not begin until a specific person or extension is reached. However, a station-to-station call costs less than a person-to-person call. The costs of both types of calls are based on the distance, duration, and time of day of the call.

Today, the majority of phones in many countries are equipped for Subscriber Trunk Dialling (STD), known as Direct Distance Dialling (DDD) in the United States and Canada. This allows a long-distance call to be dialled direct by the person making the call.

Overseas calls. A person in a country in the International Direct Dialling (IDD) system, known as the International Subscriber Dialling (ISD) system in Australia and New Zealand, can dial direct to about 220 other countries. Other overseas calls are made through a local or an international operator. Most overseas calls are transmitted by undersea cables or by communications satellites. A few overseas telephone calls are sent by direct radio waves without the use of satellites.

Special telephone services

Private lines are used by organizations that send many messages between two or more places. For example, a company might receive daily reports from branch offices throughout the country. The company has private lines to each branch.

A number of special services are provided by private telephone lines. Typewritten messages can be sent over a private line by an instrument called a *teleprinter* (see **Teleprinter**). A similar device, called a *teletypesetter,* receives messages over a line and sets them in type automatically (see **Teletypesetter**). *Facsimile machines,* also known as fax machines, use telephone lines to transmit documents and letters (see **Facsimile**). Drawings, photographs, and similar information can then be sent between them. Computers also send vast quantities of information over telephone lines.

Answering services give and take phone messages for people who are away from their office or home. Some answering services inform a person that he or she has a message by beeping a signalling device carried by the person. An automatic answering machine answers the phone automatically, gives recorded information to callers, and records their messages.

Mobile telephones provide two-way radio communication for travellers on land, on water, or in the air. In some countries, many cars, trucks, trains, and ships are equipped with mobile phone units.

Conference calls enable three or more people anywhere in the world to talk together at the same time.

Computer services. Vast amounts of computer data travel through the telephone network. Many people use personal computers or computer terminals to contact other computer users or to obtain information. Using a computer to communicate over telephone lines requires a piece of equipment called a *modem.* This device translates outgoing computer signals into signals the telephone network can use, and it translates incoming telephone signals into computer signals.

The telephone industry

The telephone industry, also known as *telecommunications,* is one of the most powerful and profitable industries in the world. In many countries, telecommunications were once government-owned, but in the 1980's and 1990's, the government has privatized the telephone companies. Private investment has financed new technology and encouraged international cooperation. In some countries, continuing research is steadily improving the existing systems. New inventions are changing the way in which people around the world communicate with one another.

Australia. In 1992, Australian Overseas Telecommunications Company (AOTC) and Telecom Australia merged to form a new company, Telstra Corporation. Telstra is publicly owned. A private company, OPTUS, has also been introduced. Australia is an important user of the INTELSAT satellite communications network.

India has an integrated network of public telephone companies which include Telecommunications Consultants India, and Mahanagar Telephone Nigam. Another company, Videsh Sanchar Nigam, is responsible for international telecommunications via submarine cables, and satellites. In 1993, the satellite INSAT-2B was launched for use in the international service. Indian scientists immediately began working on a new satellite system, the INSAT-3 series.

Indonesia has an advanced system of telephone exchanges, telex and telegraph services, and cable systems. In 1985, a submarine cable system was installed to improve the international service, especially with other Southeast Asian countries.

Ireland. In the Republic of Ireland, the telephone system is controlled by a government-sponsored body called Telecom Éireann. Its board of directors is appointed by the minister for communications.

Alexander Graham Bell called Chicago from New York City in 1892 to demonstrate the use of the telephone to businessmen.

Japan. In 1985, new laws created two types of telecommunications companies in Japan. Companies such as Nippon Telegraph and Telephone (NTT) and Kokusai Denshin Denwa (KDD) were allowed to build and operate their own networks. Secondary companies could lease circuits on those networks. KDD is constructing submarine cables that will link Japan with Taiwan, Hong Kong, Malaysia, and Singapore.

Malaysia. Telecommunications in Malaysia are served by a private company called Syarikat Telekom Malaysia Berhad. Through a microwave long-distance system, submarine cables, and satellites, the country has one of the most modern systems in Southeast Asia.

Malta. The telecommunications system in Malta is operated by the TeleMalta Corporation, a private company whose major shareholder is the government.

New Zealand has two telecommunications companies, Telecom Corporation of New Zealand, and Clear Communications which was formed in 1990 after the deregulation of the industry. Submarine cables and satellite services connect New Zealand with the international network. There are relay stations at Auckland, Wellington, and Christchurch.

Philippines. The country's largest telephone company is the Philippine Long Distance Company (PLDT). In 1989, there were 51 telephone companies, 44 of them privately owned. The industry is under the authority and supervision of the Department of Transportation and Communications (DOTC). One of its agencies, the National Telecommunications Commission (NTC), grants franchises for the installation and operation of new facilities, such as telephone exchanges, and for cellular mobile telephone services.

Singapore. In 1993, the state-run telephone company was privatized. Singapore Telecom International, the overseas section of Singapore Telecom, is highly competitive in foreign markets. The company has been awarded contracts to develop cellular mobile telephone services in Norway, Sri Lanka, and Vietnam.

South Africa. In 1991, a new telecommunications company was formed, called Telekom. It is state-operated, and the government is the only shareholder. Transmission is provided by a microwave system and by fibre-optic cable. A relay station for operation in the INTELSAT system has been established at Hartebeesthoek, near Pretoria.

United Kingdom. British Telecom (BT) runs the main telephone system. BT was entirely state-owned until 1984 when it was privatized. Mercury Communications, a private company, also runs a public telephone system, connecting with BT lines. The Office of Telecommunications (Oftel), a government regulatory body, monitors and enforces the licensing regulations for the industry.

United States. Private companies own and operate the telephone systems. The Federal Communications Commission (FCC), an agency of the United States government, regulates rates and services for interstate telephone communications. Telephone rates within the states are regulated by public utility commissions.

West Indies. A microwave transmission system operates in 16 islands between Trinidad and Tortola. A fibre-optic cable runs from Tortola to Bermuda where it links with systems to Hong Kong, London, New York, and Tokyo. The region is also connected to the United States by a submarine cable from Florida to Puerto Rico, the Dominican Republic, Haiti, and Jamaica.

History

Bell's invention. Alexander Graham Bell, a Scotsman who settled in the United States in 1871, invented the telephone. Bell was a teacher of the deaf in Boston. At night, he experimented with a *harmonic telegraph,* a device for sending several telegraph messages at once over one wire.

On June 2, 1875, one of the metal reeds of the harmonic telegraph stuck. Bell's assistant, Thomas Watson, snapped the reed to loosen it. Bell, who was in another room, heard the sound in his receiver.

On March 10, 1876, Bell finally succeeded in speaking words over a telephone. He was about to test a new transmitter. In another room, Watson waited for the test message. Suddenly, Bell spilled some acid from a battery on his clothes. He cried out: "Mr. Watson, come here. I want you!" Watson rushed into the room, shouting: "Mr. Bell, I heard every word you said—distinctly!" Bell had invented the first telephone.

In June 1876, Bell exhibited his telephone at the Centennial Exposition in Philadelphia. Scientists praised his work. But the public showed little interest until early in 1877, when Bell gave many demonstrations of his telephone equipment.

Early telephones. In October 1876, Bell and Watson held the first two-way long-distance telephone conversation. They spoke between Boston and Cambridge, Massachusetts, U.S.A., a distance of 3 kilometres.

The first telephones used no switchboards. A pair of iron wires connected each pair of phones. One person called another by pushing a knob on the telephone. This caused a hammer to make a thumping sound that went over the telephone line to the other phone. As more telephones came into use, each was connected to all the other phones. More than 1,000 connections were required to link only 50 telephones. Switchboards

The development of the telephone

The first telephone was this device, invented in 1876 by Alexander Graham Bell.

An 1882 wall phone had a hand-held receiver and a crank to signal the operator.

A 1919 dial telephone required complex switching equipment.

The 1928 desk telephone combined receiver and transmitter in a handset unit.

The "300" model desk phone, introduced in 1937, contained a bell in its base.

The coloured telephone of 1954 gained widespread popularity as a decorative item.

The "trimline" telephone of 1968 featured push buttons on the handset.

A cordless phone of 1989 allowed calls from the base or portable handset.

solved this problem by bringing together the wires from all telephones in an area.

The first telephone company in the United Kingdom (UK), the Telephone Company Limited, opened its first telephone exchange in London in August 1879. The exchange had 10 *subscribers* (customers). By the 1890's, the UK had 45,000 telephones, controlled by companies, by the Post Office, or by local government authorities.

Ireland's first telephone exchange was opened in Dublin in 1880, with five subscribers. Three private companies—the United Telephone Company, the Telephone Company of Ireland, and the National Telephone Company—successively ran the system.

Australia's first telephone service started in 1878. New Zealand's first telephone exchanges, in Auckland and in Christchurch, opened in 1881. Also in 1881, the first Indian telephone service was introduced in Calcutta. In South Africa, the first telephone exchange was opened in 1882, in Port Elizabeth, Cape Province.

Telephone improvements. Almon Strowger, an American inventor, patented an automatic step-by-step switching system in 1891. The caller pressed buttons to get the number, then turned a crank to ring the phone. In the same year, Brussels, Marseille, and London were linked by telephone.

In 1896, the first dial telephones went into operation in Milwaukee, Wisconsin, U.S.A. Transcontinental telephone services began between New York City and San Francisco, California, in 1915. Transatlantic radiotelephone services between New York City and London began in 1927. The first long-distance coaxial cable linked New York City and Philadelphia in 1936.

In 1947, the transistor was invented by scientists of Bell Laboratories, the research and development organization of the Bell System. This electronic device is smaller than the valve and requires less power. Underseas telephone cables between the United States and Europe began operating in 1956. A cable between Japan and the United States began in 1964. In 1961, Bell scientists developed the first continuously operating *laser,* a device that amplifies light. A light beam from a laser can carry many more phone calls than wires or radio waves can. See **Laser**.

In 1960, the United States began launching communications satellites. The first, *Echo,* was a huge, shiny balloon that simply reflected radio signals from one ground station to another. *Telstar, Relay,* and *Syncom* satellites used electronic equipment to amplify the signals. The first commercial communications satellite, *Early Bird,* was launched in 1965. The *Early Bird* satellite provides 240 two-way telephone circuits between Europe and the United States.

Recent developments. In 1970, International Direct Dialling (IDD) began operating between New York and London. IDD, which now serves many countries throughout the world, enables people to dial overseas directly. In 1980, a fibre-optic system for transmitting local calls was installed in Atlanta, Georgia, U.S.A. In a fibre-optic system, telephone conversations travel on beams of laser light through hair-thin strands of glass. A fibre-optic system between New York City and Washington, D.C., began in 1983. Fibre-optic cables began carrying messages across the Atlantic Ocean in 1988 and across the Pacific Ocean in 1989.

During the early 1980's, licences were granted in some countries for companies to build and operate mobile telephone systems based on *cellular radio* technology. In these systems, a city is divided into districts called *cells,* each of which has a low-powered radio transmitter and receiver. As a phone-equipped car travels from cell to cell, a computer transfers a call from one transmitter and receiver to another without interrupting the conversation. Cellular mobile telephone service can handle many more calls than earlier systems, which used one high-powered transmitter and receiver for an entire city.

Related articles in ***World Book*** include:

Biographies

Bell, Alexander Graham
Berliner, Emile
De Forest, Lee
Edison, Thomas Alva
Pupin, Michael I.

Other related articles

Cable
Cellular telephone
Communication
Computer
Electromagnet
Headphones
Intercom
Radio
Telecommunication
Television

Outline

- **I. How a telephone works**
  - A. The dialling mechanism
  - B. The transmitter
  - C. The receiver
- **II. How a telephone call travels**
  - A. Lines for local calls
  - B. Long-distance lines
- **III. Telephone services**
  - A. Local calls
  - B. Long-distance calls
  - C. Overseas calls
- **IV. Special telephone services**
  - A. Private lines
  - B. Answering services
  - C. Mobile telephones
  - D. Conference calls
  - E. Computer services
- **V. The telephone industry**
  - A. Australia
  - B. India
  - C. Indonesia
  - D. Ireland
  - E. Japan
  - F. Malaysia
  - G. Malta
  - H. New Zealand
  - I. Philippines
  - J. Singapore
  - K. South Africa
  - L. United Kingdom
  - M. United States
  - N. West Indies
- **VI. History**

Questions

Who invented the telephone?
What were the first words spoken over the telephone?
Who was Thomas Watson? Almon Strowger?
Where was the first telephone line installed?
What is a *conference call*?
What is *carrier transmission*?
When and where was the first dial telephone used?
How are satellites used in telephone communication?
What are the three main parts of a telephone?

Telephone tapping, or wiretapping, usually means the interception of telephone conversations by a listening device connected to the telephone wire or placed nearby. The message may be heard live, or it may be recorded or transmitted to another location.

Telephone tapping is sometimes used as part of an investigative procedure called *audio surveillance.* The term *wiretapping* sometimes refers to the use of any electrical or electronic device to eavesdrop on private conversations. However, the interception of nontelephone conversations is usually called *bugging* or *electronic eavesdropping.*

Sophisticated methods and devices permit eavesdropping in almost any situation. Some types of microphones may be attached to a wall or a door so that conversations can be overheard through the partition. Directional microphones may be beamed or focused to pick up conversations from long distances. Even greater distances can be overcome by concealed miniature microphones and transmitters that send messages to a radio receiver.

In most countries, the right of people to speak freely in their homes and businesses and in public places—without fear of eavesdroppers—is considered extremely important. Many nations have passed laws restricting or prohibiting various types of electronic surveillance. But much illegal eavesdropping continues, both by individuals and by governments.

In many countries, law enforcement agencies have the power to intercept telephone conversations in the interests of justice or national security. Police forces obtain permission for telephone tapping by court order or warrant in specific cases. Generally the police are not allowed to pass on the information or to use it for any purpose other than that for which the order or warrant was issued.

History. When the telephone came into regular use, government departments could listen to telephone conversations without breaking the law. During the 1930's, in both the United Kingdom and the United States of America, rules were made allowing government departments to arrange telephone tapping in matters of public importance. In the 1960's, telephone tapping became more common and public opinion began to question its use. Later legislation defined government powers more closely and set up safeguards. In 1972, the Watergate scandal in the United States centred on the telephone tapping of the Democratic Party's national headquarters during the reelection of President Richard Nixon.

Telephoto, also known as *wirephoto,* is a way of sending pictures by wire or radio. A scanning light at the sending station *scans* (passes back and forth over) a picture. The light reflected from the picture is converted into an electric current by a photoelectric cell (see **Electric eye**). At the receiving station, the electric current is converted into a light beam. The light beam then hits a film or photographic paper in proportion to the strength of the current. The picture is reproduced because the film or paper is sensitive to light.

After development, the photographic film may be used for contact printing or conventional enlarging. It may also be retransmitted by wire or radio. Telephoto differs from the system called *facsimile,* which reproduces pictures by passing an electric current through chemically treated paper (see **Facsimile**).

Teleprinter is an electromechanical typewriter that transmits electrical impulses over a wire to a receiver which prints a message. As the typist strikes each key on the transmitter, it activates electrical impulses that make a similar letter arm react at the receiving end. Teleprinter machines are often connected in series, and many receivers in different parts of the world can be run from one transmitter at the same time.

News wire services pioneered the use of the teleprinter in the early 1950's. Today, the teleprinter is being rapidly replaced by computerized satellite transmissions that relay the news directly to newsroom computers.

TelePrompTer. See **Television** (Performers and presenters; picture: A television production).

Telescopes enable us to view distant objects and study the universe far beyond earth. Telescopes vary greatly in size from those used by amateur astronomers, *above,* to huge instruments in observatories, *top right.* Some telescopes orbit the earth in satellites, *bottom right.*

Telescope

Telescope is an instrument that magnifies distant objects. Astronomers use telescopes to study the planets, stars, and other heavenly bodies. Without telescopes, we would know little about the universe beyond our own planet.

Telescopes vary in shape and size from huge bowl-shaped reflectors that measure up to 305 metres across to small binoculars and gunsights. Binoculars are actually two telescopes joined side by side. In most telescopes, a lens or mirror is used to form an image of an object. The image may be viewed through an eyepiece or recorded on photographic film or by electronic devices.

The most familiar telescopes are *optical telescopes.* These instruments, like our eyes, see visible light. But objects in space give off many other kinds of radiation that people cannot see, such as radio waves and X rays. Astronomers use other kinds of telescopes to observe this radiation.

The Dutch optician Hans Lippershey probably made the first telescope in 1608, when he mounted two glass lenses in a narrow tube. Within a year, the Italian astronomer Galileo built a similar device and became the first person to use a telescope to study the sky. Galileo soon made discoveries that revolutionized astronomy. For example, he discovered that several moons revolve around Jupiter. In 1668, the English astronomer Isaac Newton built a telescope that used a mirror. Today, most large research telescopes use mirrors instead of lenses.

What telescopes do

Telescopes produce a clear image of objects too far away to be seen by the unaided human eye. Telescopes used by amateur astronomers enable them to see about 100 times more detail than the unaided eye can see. Even large, powerful telescopes in observatories cannot reveal much more detail because the earth's atmosphere blurs the images of stars and other heavenly bodies. To escape this blurring, scientists launched the Hubble Space Telescope to operate above the atmosphere. A telescope's ability to see objects in fine detail is called its *resolution.*

Telescopes can also detect extremely faint objects. In optical telescopes, this ability depends on the amount of light the telescope can collect. The larger the telescope's light-gathering lens or mirror, the more light the telescope can collect. Large telescopes can gather about 1 million times more light than the human eye can and so detect objects about 1 million times fainter.

Visible light is only one of the many kinds of *electromagnetic radiation* that reach the earth from space. This radiation moves through space in patterns called *waves* that differ in *wavelength.* Wavelength is the distance between the crest of one wave and the crest of the next. The chief types of electromagnetic radiation—in order of increasing wavelength—are gamma rays, X rays, ultraviolet rays, visible light, infrared rays, and radio waves. Astronomers use special telescopes with electronic detectors to make images of invisible forms of electromagnetic radiation.

Some types of electromagnetic radiation, including visible light and certain radio waves, pass through the atmosphere and can be studied from the earth. But the atmosphere blocks other types of radiation—particularly ultraviolet rays, X rays, and gamma rays. Astronomers use telescopes aboard satellites to observe these forms of radiation.

Telescopes with devices called *spectrometers* enable astronomers to study individual wavelengths of electromagnetic radiation. These devices spread and separate wavelengths of radiation to form a pattern called a *spectrum.* Astronomers use spectrometers to determine the temperature and chemical composition of stars, planets, and gas clouds, and to calculate how fast an object is approaching or moving away from the earth.

Optical telescopes

Optical telescopes vary greatly in size. Binoculars may have lenses about 2.5 centimetres in diameter. A huge observatory telescope may have a mirror 6 metres in diameter. But both telescopes operate according to the same optical principles.

How optical telescopes work. Optical telescopes use a lens or mirror to collect and focus light waves. Each wave from a faint star is so weak that it can only be detected if its energy is concentrated by a lens or mirror. A lens or mirror makes the crest of a wave come together at a point called the *focus.* Waves from stars in different locations in the sky meet at different focuses, but all of the focuses lie at an equal distance from the lens or mirror in an area called the *focal plane.* The distance from a lens or mirror to the focus is called the *focal length.*

In the simplest telescopes, astronomers place photographic film at the focal plane to record images of objects in space. For direct observation, images can be magnified by an eyepiece. Most eyepieces consist of two small lenses. A viewer focuses the telescope by adjusting the eyepiece to change the distance between the eyepiece and the light-gathering lens or mirror. The eyepiece also has a focal length. The magnifying power of a telescope can be found by dividing the focal length of the lens or mirror by the focal length of the eyepiece.

Types of optical telescopes. There are three main types of optical telescopes: (1) refracting telescopes, (2) reflecting telescopes, and (3) refracting-reflecting telescopes.

Refracting telescopes, also called *refractors,* have a large lens called an *objective lens*—or simply an *objective*—at one end of a long, narrow tube. The objective is *convex* (curved outward) on both sides so that the middle of the lens is thicker than the edges. The glass slows the light waves as they pass through the lens. A wave is slowed most in the middle of the lens, where the glass is thickest. The lens thus causes the entire crest of the wave to arrive at the focus at the same time.

Refractors with a magnifying eyepiece invert the image so that it appears upside down. Astronomical observations do not require an upright image. But telescopes used to observe objects on the earth, such as binoculars, gunsights, and surveying equipment, use additional lenses or prisms to turn the image right side up again.

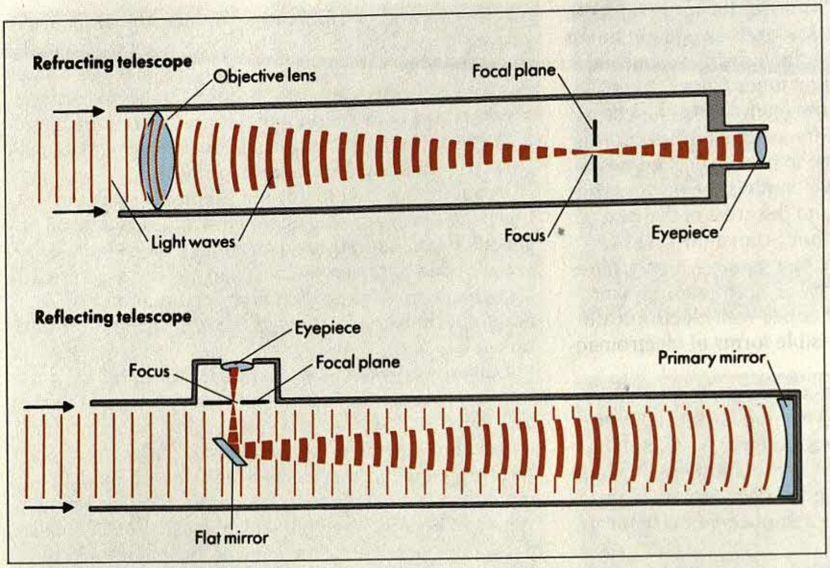
Galileo made all of his discoveries using refracting telescopes. Galileo's instruments and other early refractors, however, produced images with rainbow colouring around the edges called *chromatic aberration.* This colouring appeared because a lens slows blue light more than red, giving blue light a shorter focal length. When white light, the light which consists of all colours, passes through a lens, only one of the colours focuses correctly.

Reflecting telescopes, also called *reflectors,* use bowl-shaped mirrors instead of lenses. The mirror, called the *primary mirror,* has a surface shaped so that any line across the centre of the mirror is a *parabola,* a curve like the path of a ball batted high in the air. A mirror with that shape, called a *parabolic mirror,* reflects light rays to a sharp focus in front of itself. There, a second mirror reflects the rays to an eyepiece.

Astronomers generally prefer reflecting telescopes to refracting telescopes. The weight of a large lens can cause it to bend and become distorted. But a large, heavy mirror can be supported from behind. As a result, mirrors can be made much larger than lenses and, thus, can gather more light. In addition, parabolic mirrors are useful because they can collect infrared and some ultraviolet rays as well as visible light.

Isaac Newton designed one of the first reflectors in 1668 to avoid chromatic aberration caused by lenses. In his design, Newton used a small, flat mirror to reflect light from the primary mirror to an eyepiece at the side of the telescope tube. In 1672, a French telescope maker known only as Cassegrain designed a telescope using a small convex mirror in front of the primary mirror. The small mirror reflected the light through a hole in the primary mirror to an eyepiece behind it. This design, called a Cassegrain telescope, is used most frequently by astronomers today for optical and infrared telescopes.

The mirrors of early reflecting telescopes were shaped like a section of a sphere. A spherical mirror is much easier to polish than a parabolic mirror, but it does not focus light properly. Astronomers developed techniques to make parabolic mirrors in the early 1700's. Early mirrors were made of *speculum metal,* a heavy mixture of copper and tin that tarnished easily and required repeated polishing. In the mid-1800's, the German chemist Justus von Liebig learned how to deposit a thin coating of silver on glass to produce a brilliantly reflecting surface. When the surface tarnished or dulled, the mirror could be recoated without having to polish it. Today, all reflecting telescopes have glass mirrors, most of which are coated with aluminium.



How optical telescopes work

Optical telescopes form an image of a star or other heavenly body in two ways. In a refracting telescope, light waves enter a glass lens, which concentrates each wave crest at a point called the focus. There, an image is formed that can be viewed with an eyepiece. In a reflecting telescope, a bowl-shaped mirror reflects the light waves to a focus. This design, called a Newtonian telescope, uses a small, flat mirror to reflect the light to an eyepiece at the side.

Refracting-reflecting telescopes, also called *catadioptric* telescopes, have a large lens at the front end of the tube and a large mirror at the rear. These telescopes use spherical mirrors instead of parabolic mirrors. The lens, however, refracts light rays slightly to correct the reflective errors caused by a spherical mirror.

Bernhard Schmidt, a German optician, invented the catadioptric telescope in 1930. The telescope forms images of a larger region of the sky than is possible with any other telescope design. Astronomers have used large Schmidt telescopes to photograph the entire sky.

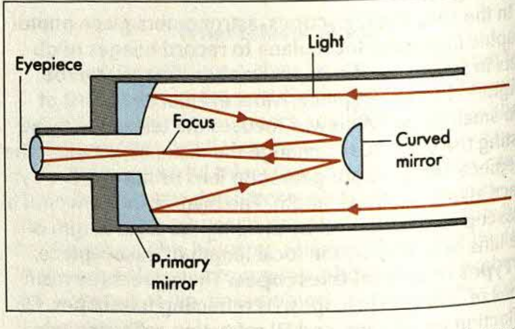
Recording images produced by optical telescopes. Astronomers often use photographic plates or film to record the images formed by an optical telescope. If film is exposed to a dim star or other object for a long time, a bright picture results. For this reason, photographs of the sky taken through a telescope reveal many details that cannot be seen with the eye. In the mid-1970's, electronic detectors called *charge-coupled devices* (CCD's) began to replace film. CCD's convert light into an electric charge, which is used to form images on a computer screen. CCD's produce better pictures than photographic plates or film because they are far more sensitive to light. Using CCD's, astronomers can see extremely faint galaxies in almost any part of the sky. Some of these galaxies are so far away that their light began its journey toward the earth long before the earth formed about $4\frac{1}{2}$ billion years ago.

Limitations of optical telescopes. Astronomers can see galaxies across the universe with big optical telescopes. The images are blurred, however, by the earth's atmosphere. Wind and daily heating and cooling of the atmosphere create pockets and swirls of warm and cool air. These differences in air temperature affect the direction and speed of light through the air. As a result, the waves of starlight arrive at the focus at slightly different times, spoiling the image. When atmospheric conditions cause little blurring, astronomers say that "seeing" is good.

Since the late 1970's, astronomers have discovered that they can improve seeing by insulating and cooling observatory domes. But only a telescope operating above the atmosphere can escape all blurring. One such telescope, an orbiting observatory called the Hubble Space Telescope, was launched into orbit in 1990. However, a flawed mirror prevented the telescope from working as well as scientists hoped. In 1993, astronauts replaced some lenses and installed a new camera to compensate for the flaw. As a result, the Hubble has produced sharper, more finely detailed images than any telescope on the earth.

Radio telescopes

Radio telescopes collect and measure faint radio waves given off by objects in space. An American engineer, Karl G. Jansky, discovered radio waves from space in 1931. Early radio telescopes found that the sun and the centre of our galaxy were strong sources of radio waves. They also detected strong radio waves coming from dark areas of space. These sources were discovered to be the remains of exploded stars and a rare type of distant galaxy. Since then, astronomers using radio telescopes have discovered objects in space that had been missed by optical telescopes. These discoveries



A Cassegrain reflecting telescope uses a primary mirror with a hole in the centre to reflect light to a smaller, curved mirror. The smaller mirror reflects the light through the hole, where it may be viewed with an eyepiece or recorded.

include giant clouds of gas molecules; *pulsars,* collapsed stars that send out regular pulses of radio waves; and *quasars,* extremely distant starlike objects that produce enormous amounts of radiation.

How radio telescopes work. Most radio telescopes use a large parabolic reflector, often called a *dish aerial* or simply a *dish,* to collect radio waves from space. The dish has the same shape as the parabolic mirror of a reflecting telescope. Radio waves, however, are much longer than light waves. As a result, a radio telescope's dish need not be polished or shaped as accurately as the mirror of a reflecting telescope. But it must be much larger in diameter to focus the long radio waves. The reflector focuses the waves onto an aerial that changes them into electric signals. A radio receiver amplifies these signals and records their strength at different frequencies and from different directions as data on a tape. The data are analysed by a computer, which combines the signals from the receiver. The computer then uses the signals to draw a picture of the source of the radio waves or to analyse the radio spectrum and chemical composition of the source.

Large radio telescopes are also used as giant radar systems to map the surfaces of the moon and the planets. Astronomers send powerful radio waves to the moon or planet and then record the radio echoes that bounce back. Astronomers call this technique *radar mapping.*

Types of radio telescopes. In most radio telescopes, motors turn the reflector toward any source of radio waves in the sky. The largest moving dish measures 100 metres across. Astronomers can use a single large fixed dish to study radio signals from a faint object. The world's largest radio telescope is a fixed dish built into a bowl-shaped valley near Arecibo, Puerto Rico. The dish measures 305 metres in diameter. It is often used for locating and measuring pulsars.

Astronomers produce extremely sharp radio images by combining signals from many radio dishes spread over large distances. At a central station, computers electronically combine the radio signals from various locations, introducing time delays between the signals from the different dishes. These delays cause the signals from a radio wave to come together at the same time and reinforce each other, just as a light wave is concentrated at the focus by a mirror or lens. Radio telescopes connected in this way are called a *radio interferometer.* The longer the *baseline* (distance) between the telescopes, the better the resolution of the interferometer. Astronomers use interferometers to make radio maps of the sky.

The most powerful radio interferometer is called the Very Large Array (VLA). It stands on a high plain near Socorro, New Mexico, U.S.A. It has 27 dishes, each measuring 25 metres in diameter. Another important interferometer, the Very Long Baseline Array (VLBA), was completed in 1993. The system consists of 10 reflectors located across the United States from Hawaii to the Virgin Islands. The VLBA provides the sharpest radio images ever produced.

Infrared telescopes

An infrared telescope collects *infrared* (heat) rays from objects in space. Most infrared telescopes are reflecting optical telescopes with an infrared detector instead of an eyepiece. Any object at room temperature gives off huge amounts of infrared rays because of the heat it holds. As a result, astronomers must design infrared telescopes so that heat from the telescope itself does not interfere with the radiation from space. They must also cool parts of the telescope to extremely low temperatures to detect infrared rays from the coldest sources, which are very faint. Some infrared waves from space pass through the atmosphere. But water vapour and carbon dioxide in the air block many others. For this reason, astronomers install infrared telescopes on mountaintops where the air is thin and dry. They also send infrared telescopes above the earth's atmosphere aboard high-flying planes or satellites.

In 1961, American physicist Frank J. Low built the first infrared detector sensitive enough for use in astronomy. The device, called a *bolometer,* was an extremely cold electronic thermometer in a vacuum. When infrared rays hit the bolometer, it warmed up and gave off an electric signal. Today, infrared telescopes use electronic devices called *array detectors,* similar to CCD's, to form infrared images on a computer screen.

An infrared telescope operated in orbit aboard the Infrared Astronomical Satellite (IRAS) from January to November 1983. Liquid helium cooled the entire telescope —its mirrors, detectors, and tube—to a temperature only a few degrees above absolute zero (−273.15 °C). IRAS detected rings of dust around the star Vega and other nearby stars that might be solar systems in the process of formation. Astronomers believe a similar ring of dust around the sun developed into the planets.

Other telescopes

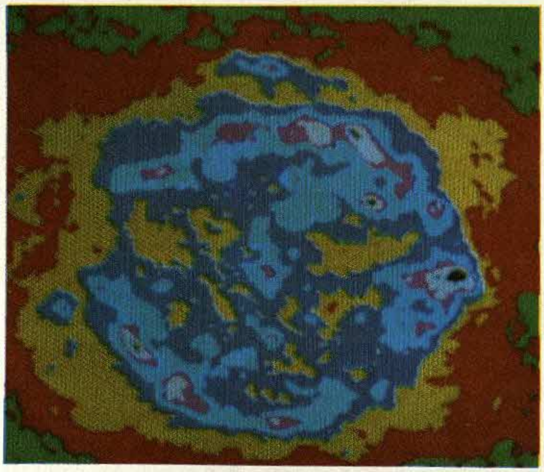
Electromagnetic radiation with short wavelengths has the highest photon energies among all the kinds of electromagnetic radiation. These forms of radiation include ultraviolet rays, X rays, and gamma rays. Because of their high energy, these rays cannot be easily reflected by a mirror, as light can. As a result, the telescopes used to observe these forms of radiation often look quite different from other telescopes. Another difference is that—except for the least energetic ultraviolet rays—the atmosphere absorbs these rays before they reach the earth. To study these high-energy forms of radiation, astronomers must send telescopes above the atmosphere on rockets or satellites.

Ultraviolet telescopes. Astronomers use reflecting telescopes in space with electronic detectors to study most wavelengths of ultraviolet rays, which can be reflected just like visible light. But the shortest wavelengths, called *extreme ultraviolet rays,* are harder to reflect. Extreme ultraviolet rays can only be reflected off a mirror at a small angle called a *grazing incidence.* This characteristic of the rays resembles how stones can be skipped along the surface of a pond.

Ultraviolet telescopes enable astronomers to study extremely hot objects in space, including quasars and stars called *white dwarfs.* Astronomers also use ultraviolet telescopes to study how stars form and the composition of gas between stars and galaxies.

X-ray telescopes. X rays have shorter wavelengths and higher energy than ultraviolet rays. X rays that are not absorbed or scattered by matter pass straight

The Very Large Array radio interferometer, located near Socorro, New Mexico, U.S.A., is one of the world's most powerful radio telescopes. It consists of 27 radio telescope reflectors, each measuring 25 metres in diameter.



A radio image of the remains of an exploded star was created by a computer from radio waves collected by the Very Large Array radio interferometer. This image shows a star that exploded about 300 years ago in the constellation Cassiopeia.

through many materials. But longer wavelength X rays, like extreme ultraviolet rays, can be reflected at a grazing incidence. Some objects in the universe give off much of their energy in the form of X rays. These X-ray sources include the centres of galaxies and clouds of extremely hot gas that lie between galaxies.

The simplest X-ray telescopes use an arrangement of iron or lead slats instead of mirrors. The slats block all X rays except those from one line across the sky. The X-ray photons then enter a detector filled with an X-ray absorbing gas, where they are counted. By scanning the sky, these telescopes can locate X-ray sources.

During the 1970's, slatted X-ray telescopes discovered many sources of X rays in space. Astronomers now know that many of the brightest X-ray sources are certain *double stars*—that is, a pair of stars orbiting each other. In these pairs, one of the stars has collapsed and become a small, dense star called a *neutron star* or a *black hole*—an invisible object with such powerful gravitational force that not even light can escape its surface. X rays occur when gas from a star falls into the neutron star or black hole.

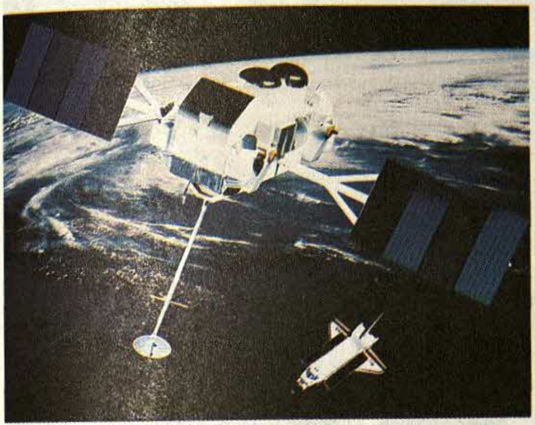
Gamma ray telescopes. Gamma rays have the shortest wavelength and highest energy of any electromagnetic radiation. When a gamma ray photon collides with an atom while passing through matter, it may knock electrons loose from the atom or even break up the nucleus of the atom. These collisions can produce a shower of subatomic particles and low-energy radiation. The shower travels in the same direction as the original gamma ray and is detected with devices called *scintillators.* When radiation or particles from a shower hit a scintillator, the instrument produces a flash of light that can be recorded. By measuring the shower, scientists can calculate the energy level of the gamma ray and the direction of its source. Gamma ray telescopes on the Compton Gamma Ray Observatory, a satellite launched in 1991, have enabled scientists to learn more about some of the least understood objects in the universe, including pulsars and quasars. Many of these high-energy objects are strong sources of gamma rays.

Recent developments in telescopes

In the 1980's, astronomers began work on a new generation of ground-based optical telescopes larger than any built before. Astronomers hope to use the telescopes to unlock many secrets of the universe, including how planets, stars, and galaxies form. These telescopes will use sensitive optical and infrared detectors and adaptive optics to produce extremely sharp images. In addition, the telescopes will have larger, more accurate mirrors than any instruments built before. Several breakthroughs in mirror design have enabled astronomers to make large mirrors that do not bend or become distorted under their own weight.

One new design is the segmented mirror, used in the Keck Telescope on the island of Hawaii, completed in 1992. The Keck's light-gathering mirror consists of 36 *hexagonal* (six-sided) mirrors mounted close together. The mirrors form a reflecting surface 10 metres in diameter. A second Keck Telescope of the same design is due to begin operating at the site in 1996.

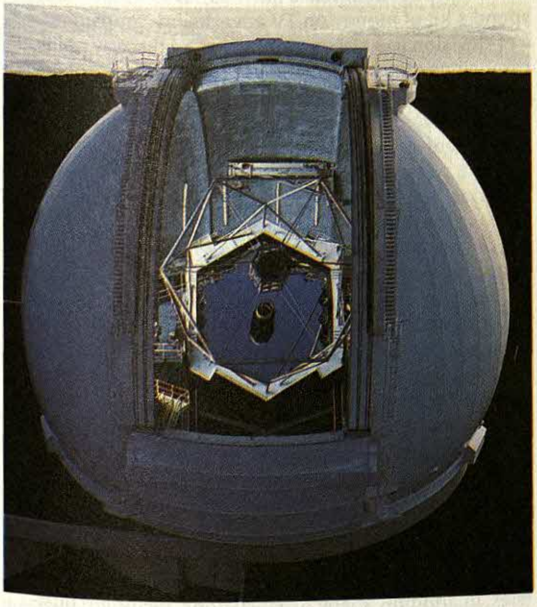
Some projects involve linking two or more telescopes to collect more light. A project called the Very Large Telescope (VLT) will consist of four telescopes with mirrors 8.2 metres in diameter. Used together, the four telescopes will have the light-gathering power of a single mirror with a diameter of 16 metres. The VLT's mirrors will consist of thin discs of glass supported by hundreds of computer-controlled devices. The devices, called *actuators,* will make continuous adjustments to maintain the mirrors' proper shape. The European Southern Observatory, led by astronomers from several European nations, is building the VLT near Antofagasta, Chile. The project is scheduled to start operations in the late 1990's.



The Compton Gamma Ray Observatory, a satellite launched in 1991, carried instruments called *scintillators* to detect gamma rays, measure their intensity, and locate their sources.

Astronomers at the University of Arizona, U.S.A., have made huge glass honeycomb mirrors. The construction process uses a mould filled with hundreds of hexagonal blocks. Melted glass covers the blocks and fills spaces between them. The blocks are removed after the glass cools, leaving a stiff glass structure that is light enough to float on water.

The Columbus Telescope, scheduled for completion in 1997, will also use honeycomb mirrors. The instrument will consist of two telescopes, each with a mirror 8.4 metres in diameter, mounted side by side like a giant pair of binoculars. The Columbus Telescope is a joint project of Italian and American astronomers. It will stand on Mount Graham in southeastern Arizona. Several other telescopes with honeycomb mirrors were under construction in the mid-1990's.



The Keck Telescope, on Mauna Kea on the island of Hawaii, has a huge segmented mirror measuring 10 metres across. The mirror consists of 36 smaller mirrors.

Both honeycomb mirrors and the VLT's thin disc mirrors are made by a new technique called *spin-casting,* developed in the mid-1980's. Spin-casting replaces the costly, laborious process of grinding a mirror to the proper parabolic shape. Instead, a huge rotating oven spins molten glass at a carefully controlled rate. The liquid glass flows into a shape that is nearly perfect for a telescope mirror.

Related articles. See **Observatory,** with its list of *Related articles.* See also:

Aberration
Astronomy (Observing with telescopes; pictures)
Binoculars
Bolometer
Galileo
Hubble Space Telescope
Jansky, Karl G.
Lens
Light (How light behaves)
Lovell, Sir Bernard
Newton, Sir Isaac (Light and colour)
Spectrometer
Sun (Studying the sun; pictures)
World, History of the (picture: New scientific devices)

Outline

- **I. What telescopes do**
- **II. Optical telescopes**
  - A. How optical telescopes work
  - B. Types of optical telescopes
  - C. Recording images produced by optical telescopes
  - D. Limitations of optical telescopes
- **III. Radio telescopes**
  - A. How radio telescopes work
  - B. Types of radio telescopes
- **IV. Infrared telescopes**
- **V. Other telescopes**
  - A. Ultraviolet telescopes
  - B. X-ray telescopes
  - C. Gamma ray telescopes
- **VI. Recent developments in telescopes**

Questions

What is a charge-coupled device?
Why are parts of infrared telescopes cooled to low temperatures?
How does an optical telescope focus light?
Why must astronomers make radio telescopes larger than optical telescopes?
What is a grazing incidence? Why is it important in the design of some ultraviolet and X-ray telescopes?
Why do astronomers build infrared telescopes on mountaintops?
What is a radio interferometer?
Who first used a telescope to observe objects in space?
Why do astronomers usually prefer reflecting telescopes to refracting telescopes?
What causes star images to blur? How do astronomers correct blurring in optical telescopes?

Teletext. See **Television** (Televised information services).

Teletypesetter (TTS) is an electrical machine somewhat like a teleprinter (see **Teleprinter**). It sends typewriter copy over long distances and at the same time it punches holes in a paper tape. When this tape is fed into a typesetting machine, the machine automatically sets the copy in type used to print a newspaper.

The leading news wire services began using TTS to send reports to newspapers in the early 1950's. Today, wire service copy is transmitted to most newspapers by satellite. It is then fed directly into a computer and stored there until it is edited on a visual display terminal (VDT). This new system, though more expensive than the earlier TTS, is more than 20 times faster.

The Olympic Games

Sports events

"Sesame Street"

Learning and fun for children

WMAQ-TV (Chicago) news

The latest news

"Wheel of Fortune"

Game shows

Television is sometimes called "the device that brings the world into the home." TV provides millions of home viewers with a wide variety of entertainment, information, and special events. The pictures on this and the following page show some examples of television's far-reaching coverage.

Television

Television, also called TV, is one of our most important means of communication. It brings pictures and sounds from around the world into millions of homes. Communications satellites in space relay TV pictures across oceans and continents. People with a television set can sit at home and watch a national leader make a speech or visit a foreign country. They can see a war being fought, and watch government leaders try to bring about peace. Through TV, viewers can see and learn about people, animals, and things in faraway lands. Millions of people around the world can watch sports events, such as the Olympic Games, and other events of worldwide interest. Television even takes viewers out of this world with coverage of space flights.

In addition to all these things, television brings its viewers a steady stream of programmes that are designed to entertain. In fact, TV provides many more entertainment programmes than any other kind. The programmes include action-packed dramas; light comedies; fictional serials, called soap operas; sporting events; cartoon, quiz, and variety shows; and feature films.

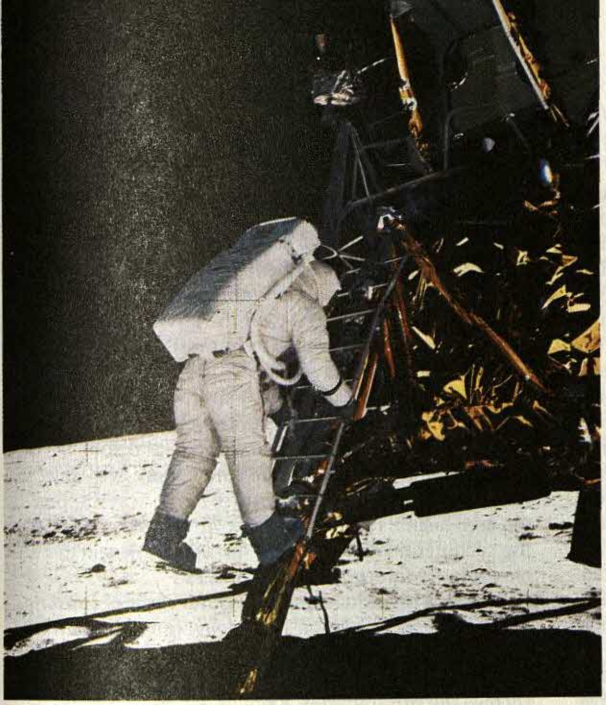
In industrial nations such as Australia, Japan, the United States, and the countries of western Europe, almost every home has at least one TV set. In the United States, about 65 per cent of homes have two or more sets. On average, a TV set is in use in an American home for about 7 hours each day. In many other countries, television is still an expensive luxury that few people can afford. In Zaire, in Africa, for example, there are only 20,000 TV sets in a country of over 35 million people.

In some countries with a high proportion of television viewers, TV has become a major way to reach people with advertising messages, called *commercials.* In the United States, for example, most television stations carry hundreds of commercials each day. Major companies spend a lot of money on TV advertising campaigns.

Television has also greatly changed the way political campaigns are run. Before TV, candidates for public office relied chiefly on public appearances to urge people to vote for them. Today, candidates for high office can reach many more people through TV than they can reach in person. In some countries, politicians are allowed to buy advertising time on television.

The name *television* comes from a Greek word meaning *far* and a Latin word meaning *to see.* Thus, *television* means *to see far.* Most pictures and sounds received by a TV set are beamed from a TV station on electronic signals called *electromagnetic waves.* The television set changes these waves back into pictures and sounds.

Many scientists contributed to the development of television, and no one person can be called its inventor. Experiments leading to the invention of TV began in the 1800's, but progress was slow. Television as we know it today was not developed until the 1920's, and it had little importance in communication until the late 1940's. But during one 10-year period—the 1950's—it became part of most households in industrial nations. Since then, television has gained importance in most other countries. In addition, many organizations, including businesses, hospitals, and schools, now use television for their own special purposes.



Space exploration

Family comedy shows

Soap operas

Uses of television

There are two main kinds of television stations: commercial stations and public stations. *Commercial television stations* are run by private companies. They sell advertising time to pay for their operating costs and to make a profit for the companies that run the stations. *Public television stations* are nonprofit organizations, and are run under special arrangements. The British Broadcasting Corporation (BBC), for example, is financed from the licence fees paid by owners of television sets in the United Kingdom (UK). It does not sell advertising time. In most countries, public television stations rely on business, government, and public contributions to pay for their operating costs, and they make their own decisions about programme contents. In some countries, stations are almost entirely paid for and run by the government, which makes, or influences, decisions about programme contents. Such stations generally do not sell advertising time.

In some countries, people can also subscribe to *cable television* systems and *satellite broadcasting* systems. Viewers pay a fee for these subscription services.

Television also has many uses other than broadcasting programmes to the home. For example, schools, businesses, hospitals, and many other organizations use *closed-circuit television.* In closed-circuit TV, signals are sent—by way of wires—to certain television sets only rather than to all sets within the area that broadcast signals could reach in the ordinary way.

Since the late 1970's, such equipment as video cassette recorders, videodisc players, and personal computers have changed the way people use television in their homes. For example, TV sets may be used for such purposes as playing electronic games and receiving televised information services.

Commercial television. Most commercial television stations broadcast more entertainment programmes than any other kind. These shows include light dramas called *situation comedies;* action-packed dramas, often about detectives, doctors, lawyers, or police officers; variety shows featuring comedians, dancers, and singers; and feature films, including some made expressly for television. Entertainment programmes also include game or quiz shows, *soap operas* (melodramatic serials), and cartoons and other children's shows.

Another kind of commercial television programme is the *documentary.* A documentary is a dramatic, but nonfictional, presentation of information. Some TV documentaries entertain as well as inform. These include travel programmes about people, animals, and things in faraway lands. Television also presents documentaries about such serious social issues as alcoholism, drug abuse, poverty, and racial prejudice.

Some commercial television stations broadcast *discussion,* or *talk,* shows. On these shows, a host interviews people from many different walks of life—including authors, film and TV stars, politicians, and sports personalities.

Commercial television stations may also broadcast sports events—from athletics and cricket to football and tennis. Every four years, TV brings its viewers the excitement of the Olympic Games—often from halfway around the world.

Most commercial television stations broadcast programmes of local, national, and international news every day. Also, stations often interrupt their regular programme schedules to present extended coverage of special events.

Advertising makes up an important part of commercial television. Television commercials appear between and during most programmes. The vast majority of the commercials urge viewers to buy some kind of product —from dog food and hair spray, to cars and insurance policies. Public service advertisements concern such issues as public health and road safety.

Advertising provides the finance for commercial television, and in some cases provides partial finance for public broadcasting stations. Each television company sells advertising time to advertisers or to advertising agencies. Advertising may be limited to the beginning and end of a programme, or to a *natural break* (interval) in the programme. The charge for advertising depends on the size of the audience at the time the advertisement is broadcast. Advertising at peak viewing times is much more expensive than at other times. In some countries, advertisers can sponsor or "buy" a programme, and have their name associated with it.

Regulatory bodies, such as the Australian Broadcasting Tribunal, are responsible for the licensing of television stations. These bodies work with advertising standards authorities to maintain the quality of broadcast advertisements. Such bodies may fix the maximum amount of advertising allowed on television in an hour, averaged over the day. Some types of programmes have no advertising. In the United Kingdom, for example, these include religious programmes and broadcasts for schools. During the 35 hours of evening broadcasting in a typical weekly schedule of a television station, there might be 98 advertising "spots." About half would occur between programmes, and half in natural breaks. See **Advertising.**

Public television stations usually broadcast more educational programmes and programmes on cultural subjects than do most commercial television stations. Because public television stations do not rely on advertising to stay in business, it is not necessary for them to attract huge audiences.

Some public television stations broadcast educational programmes on a wide range of subjects—from literature and physics to cooking and yoga. Some educational programmes, such as the Open University programmes broadcast by the BBC, take much the same form as classroom instruction. But others, such as the U.S.-made "Sesame Street", a children's show, use a more entertaining approach.

Public television stations offer viewers many programmes that combine entertainment and cultural enrichment. They broadcast such things as ballets, concerts, operas, plays by leading dramatists, and surveys of art and history.

News and current affairs programmes make up an important section of programming for most public television stations. Many stations provide news bulletins throughout the day, with a main national news programme in the evening. In addition, there may be programmes dealing specifically with local and regional news. Some public television stations also have programmes in which journalists and others who are concerned with current events discuss topics in the news. Politicians may be interviewed about important matters of the day. In some programmes, studio audiences are invited to put questions to a panel of guests or to join in discussion of a particular topic or topics.

Cable television is a television service that viewers pay for by subscription. Commercial and public television stations send signals over the airwaves. Cable television signals are delivered to home TV sets of most of their customers by way of cables. Some cable systems carry more than 100 channels—far more than can be broadcast over the airwaves even in the largest urban areas. Many cable channels are devoted to specific types of programming. For instance, there are cable channels that specialize in feature films, news, sports, the arts, health, religion, or minority programmes. See the section on *Transmitting television signals* in this article for more information on cable TV.

Satellite broadcasting is another form of subscription television. The signals are delivered to home TV sets from a *direct broadcasting satellite* in space. The viewer must have a dish-receiver aerial, or antenna, to receive the programmes. Satellite TV companies provide specialized entertainment on a number of channels. Each channel shows one kind of programme, such as feature films, news, sports, pop music, or children's programmes and cartoons. A satellite operating over western Europe, for example, can beam the same programmes to viewers in France, Germany, the Netherlands, the United Kingdom, and other countries within its reception area. See the section on *Transmitting television signals* in this article for more information on the use of satellites.

Closed-circuit television has a number of specialized uses. Many schools and colleges have TV sets that receive special lessons by way of closed-circuit television. Also, a lesson in one class can be shown simulta-

Closed-circuit television enables hospital personnel to monitor the condition of many patients at the same time.

neously to students in other rooms through closed-circuit TV. Conventionally broadcast TV also brings into the classroom such events as parliamentary proceedings.

Businesses use videotaped television programmes extensively to train their employees. Many large companies operate their own private TV studios. Some companies conduct nationwide meetings and conferences by live TV. This procedure, called *teleconferencing,* saves the time and expense of travel.

Closed-circuit TV in banks and prisons enables guards to observe many people at once. Hospitals use closed-circuit TV to *monitor* (keep track of) patients. Television cameras are placed in operating rooms to give medical students close-up views of actual surgical procedures.

Video entertainment systems include video cassette recorders (VCR's), videodisc players, and electronic games.

Video cassette recorders enable people to tape television programmes on blank video cassettes and play them back later. The VCR is attached to the user's television set. People also may buy or rent prerecorded videotapes. Many of these are tapes of concerts, feature films, or sports events. With the use of a video camera, people can make their own videotape recordings. See **Videotape recorder.**

Videodiscs resemble records, but they carry both sound and pictures. These prerecorded programmes are transmitted by a videodisc player to an attached TV set. Videodiscs are used in the home primarily for viewing concerts and feature films.

The information on a videodisc, as on other *optical discs,* is played back by a device called a *laser* inside the player. A videodisc holds up to 54,000 pictures, or *frames,* per side and can store a vast amount of information. The images on these frames may be observed singly, like the pages of a book. They also may be played in sequence to produce a moving picture. A videodisc player provides instant access to any frame on the disc. This feature makes the videodisc useful for teaching.

In an *interactive* optical system, the videodisc player is linked to a computer. Such a system can be used in schools and colleges, and in industrial training. If a student answered a test question incorrectly, the disc might automatically respond with the appropriate information. See **Videodisc.**

Electronic games use a television screen as a game board. Such games, also called *video games,* are played on a computer-controlled unit connected to a TV set. Each video game has its own program on a cartridge that is inserted into the unit. Players operate controls that move electronic dots, lines, and other images that appear on the TV screen. See **Electronic game.**

Televised information services, sometimes called *electronic publishing,* were developed in Canada, France, and the UK during the 1970's. Televised information services provide viewers with news stories, stock market listings, and many other kinds of information. There are two main types of televised information services—*teletext* and *videotex,* or *videotext.*

Teletext is broadcast over the airwaves on ordinary television channels. An electronic control panel attached to the TV set decodes the broadcast signals and converts them into images on the screen. Teletext transmits its store of information over and over again. The user selects a particular "page" of information by typing in the appropriate code number on the control panel. Teletext is limited to a few hundred pages of information on each channel.

Videotex, also known as *viewdata,* is brought into the home over television cables or telephone lines. The viewer uses a control panel to select the data to be transmitted. The data may be displayed on a TV set or on the screen of a personal computer. Unlike teletext, videotex enables the user to conduct two-way transactions. In some communities, people can use videotex to do their shopping, banking, and pay their bills by TV.

Producing television programmes

The *production* (putting together) of a television programme is an extremely complicated process. A programme requires careful planning, much preparation, and the combined efforts of many skilled workers.

Most TV programmes—including almost all entertainment shows—are prerecorded, and then broadcast later. The recording may be done on videotape or on film. Many prerecorded programmes are produced from beginning to end, in the manner of a stage play. However, television production companies also use the *piecemeal approach* of the film industry. In the piecemeal approach, each scene is recorded separately, and *spliced* (connected together) later.

The first two parts of this section—*Planning and preparation* and *Putting a show on the air*—trace the production of a programme in a television studio. But much of the information under these headings applies to all TV productions. The last part of this section describes other production methods.

Planning and preparation

The planning of television shows begins in the programming department of the networks and stations that broadcast programmes. Members of these departments decide what programmes their companies will show. Networks and stations produce many programmes themselves. Independent producers create others, and sell them to networks and stations. In either case, once a programming department approves an idea for a programme, a *producer* takes responsibility for its production.

The producer usually begins by obtaining a script and choosing a director. Sometimes—especially for uncomplicated shows—producers write their own script. They may also serve as their own director. But more often, the producer assigns the script-writing job to a professional writer or team of writers, and the directing job to a professional director. The producer and direc-

A television production requires the combined efforts of many professionals. Newscasters must appear natural on camera as they read news stories from a TelePrompTer or Autocue, and take directions from the stage manager.

tor select the actors, actresses, or other people who will appear on the show. The producer also chooses the production specialists needed to produce the show. These people may include an art director, a costume designer, and a composer. In addition, the producer works closely with the director throughout the production process. The producer of a news programme decides which of the day's events to include in the newscast and in what order to present them.

Writers prepare the scripts for television programmes. A television script is a written account of what is to be said and done during the programme. The amount of detail a script contains varies, depending on the programme. A talk show script, for example, may include only the host's opening remarks, some of the key questions to ask the guests, and directions for any special acts that may take place during the show. During most of the show, the host and the guests carry on *ad-libbed* (unplanned) conversations. A script for a television drama, on the other hand, includes every word to be spoken by the actors and actresses. It also describes the actions they are to perform. For a newscast, writers prepare the script that the announcers read. Reporters usually prepare questions and comments for news stories they cover outside the studio.

The director. As soon as the writers complete the script, the director reads it and tries to visualize ways to translate it into an actual television programme. Directors get ideas about how the characters should speak, move, and generally behave. They decide what camera shots will be needed to create the effects they visualize. Sometimes, the director asks an artist to prepare a *storyboard* (a series of drawings) that shows how key parts of the programme will look.

Production specialists. The producer and director call on many specialists to help prepare a programme. An *art director* and artists and craftspeople who work with the art director design and build the show's scenery. A *costume designer* creates or obtains costumes needed for the production. A *property manager* gets special items called *props* for the show. These items include furniture, vases of flowers, and guns. Specialists in technical work also play a key role in the production process. They advise the producer and director on what kinds of cameras, microphones, and lights will be needed. A *production manager,* or *production coordinator,* sees to it that all the required equipment is available when needed.

Performers and presenters. A person who appears on a television programme may be a *performer,* or a *presenter.* Performers include actors, actresses, comedians, singers, and other entertainers. Television presenters appear on television as themselves. They include newscasters, sports announcers, and talk show hosts.

Selection of performers and presenters ranks among the key steps in the planning of a television programme. The producer and director do this important job. Big stars may get television roles because of their fame and proven ability. But usually, performers and presenters must *audition* (try out) for the parts they want to play. During an audition, the director and producer may ask the performers or presenters to *take a screen test* (perform in front of a camera).

Actors and actresses who obtain a job are given a script so that they can study their lines. An actor or actress may have less than a week to learn the lines for a one-hour drama production. Those who perform on a daily soap opera have only a few hours each day to memorize their lines.

Some television productions make use of *cue cards* to help actors and actresses with their lines. A cue card is a large piece of cardboard or similar material with

Production preparations include reporting news stories and videotaping the coverage for playback during the newscast, *left.* At the studio, a videotape editor and a reporter work to cut a story so that it presents only the most important information, *right.*

writing on it. The writing may be a key word or phrase, or an entire passage from a script. An off-camera stagehand holds the card up so the actor or actress can see it.

Some television presenters, such as newscasters, use an aid called a *TelePrompTer* or *Autocue.* A TelePrompTer or Autocue is a device that displays the words from a script. The display moves continuously, giving the presenter a line-by-line view of the script. The TelePrompTer or Autocue is located so that a person reading from it appears to be looking directly at the camera.

Composers and musicians. Most entertainment programmes include music. A producer and director may decide they need an original musical composition for their show. If so, the producer hires a composer. The composer meets the producer and director to discuss the theme, mood, and *climaxes* (dramatic high points) of the programme. Composers base their compositions on what they learn about the show. Often, producers and directors use existing music for their programmes. To do so, they must get permission from the holders of the copyright on the music, and pay them a fee.

The producer hires musicians and a conductor to perform the music. For prerecorded shows, the musicians often record the music after the actual programme is produced. Then, technicians combine the music with the rest of the programme.

Rehearsals are practice sessions for TV shows. Most TV productions require at least one rehearsal. Complicated productions often require many more.

During a rehearsal, the performers—under the director's guidance—practise their lines and their actions. The director also directs the actions of the camera operator and other off-camera workers.

Rehearsal for a dramatic production may begin with a *script reading.* Then, the director may call for a *dry run* (rehearsal without equipment or costumes). Many dry runs take place in a *rehearsal room.* This room has lines on the floor that indicate where such things as doors, chairs, and tables will be during the actual production. A director may watch a dry run through a *director's viewfinder.* This device resembles the viewfinder on a still camera. It enables the director to get an idea of how scenes will appear on television.

Finally, the director calls for a *dress rehearsal,* or *camera rehearsal,* in the studio. The goal of a dress rehearsal is to achieve a performance that is the same as the final production will be. In fact, directors sometimes record both the dress rehearsal and the actual production. In reviewing both recordings, directors may decide that parts of the dress rehearsal came out better than the actual production. They may then substitute the parts of the dress rehearsal they like for the corresponding parts of the actual production.

Television rehearsals stress the importance of split-second timing. A theatre drama may run as much as five minutes more than its planned time. But a television show must be timed exactly. A show cannot run even a few seconds past its planned time, because that time is set aside for the next programme.

Putting a show on the air

When the time comes to tape a programme, everything needed for the process is brought together in a television studio. Workers put the scenery and props in place in the studio. Other workers put floodlights and spotlights in place. Technicians turn these lights off and on and brighten and dim them during the production to achieve the desired effect for various scenes. Often, a single televised scene requires as many as 20 different lighting instruments. One or more microphones are put in place. Workers bring television cameras—usually at least two and sometimes four or five—into the studio.

Putting a show on the air requires the skills of many workers. Control-room monitors show scenes shot by studio cameras and scenes taped earlier. The producers work with the director in deciding which scenes go on the air, *left.* An audio engineer controls the sound, *right.*

The people responsible for the technical parts of the show's production get ready in the *control room.* This room lies near the place where the broadcast occurs.

Some studios have rows of seats, very much like a theatre. Visitors can come to these *audience areas* and watch shows being produced.

Before the show begins, makeup artists apply makeup to the people who will appear on the show. Makeup helps people look natural on camera. The performers may put on special costumes, if the show calls for such costumes. Finally, they come into the studio and perform the production before the cameras.

The cameras used for *shooting* (photographing) the production are mounted on devices that have wheels so the camera operators can move them around the studio to change the direction of their shots. Some cameras today are operated by remote control from the control room instead of by a camera operator in the studio. Most broadcasting cameras can be lowered and raised to change the vertical angles. In addition, all cameras can adjust from a close-up to a long-range view of a scene by means of a device called a *zoom lens.* The zoom lens enables the camera to vary televised scenes without moving. *Zooming* (moving in and out on scenes) is a widely used television production technique.

Microphones. Most studio TV productions involve the use of one or more *boom microphones.* A boom microphone is attached to a *boom* (long metal arm). A worker called the *boom operator* uses mechanical devices to move the microphone above and in front of the person speaking. For dramatic productions, it is essential that the microphone be kept out of camera view. Imagine a dramatic scene in which an actor lies exhausted in a hot desert, crying for help. If suddenly the boom microphone that hangs above him dropped into camera view, the scene would look ridiculous. Sometimes, television makes use of *hidden microphones*—either in addition to, or in place of, boom microphones. They may be hidden in or behind scenery or props.

Talk shows and other nondramatic productions may use boom microphones. But they also use microphones that viewers can see. These include *desk microphones,* which stand on desks or tables in front of performers; and *hand microphones,* which performers hold. Another kind of microphone, the *lavalier,* is hung around a performer's neck or attached to a performer's clothing. It may be in camera view, or hidden in the clothing.

The control room. During a television programme, scenes from each of the studio's cameras will appear on the viewer's screen. Pictures from other video sources, including filmed commercials, and slides that show titles, may also be seen. The job of determining which scene appears on the screen at a given time is performed in the control room. A programme may also include sounds from several sources. Technicians in the *audio control* section of the control room regulate the sounds. In addition, engineers operate equipment that maintains the quality of the pictures and sounds.

The control room has several *monitors* (television sets). Each monitor shows the scenes from a different camera or other video source. The director watches the monitors when choosing which scenes to put on the air. The picture that is on the air at any given time appears on a monitor called the *master,* or *line, monitor.*

An important piece of equipment in the control room is the *vision mixer* or *switcher.* This instrument has many buttons, including buttons for controlling each studio camera and each other picture source. On command from the director, a technician called the *technical director* (TD) or *vision engineer,* presses buttons to change the televised scene. If the director wants the scene being photographed by camera number 1 to be shown, he or she tells the TD to press the button for camera number 1. To change to camera number 2, the TD presses button number 2, and so on. This process goes on throughout the programme. But it is done so smoothly that viewers hardly realize it is happening.

The switcher also has levers. By moving levers in various ways, the TD can combine scenes from two or more cameras or other video sources. Such combinations are called *special effects.* They include the *dissolve,* the *super,* the *wipe,* and *matting,* or *keying.*

The *dissolve* is a gradual change from one picture to another in which the two pictures overlap briefly. A dissolve can take place slowly or rapidly, depending on how fast the TD moves the levers. Directors use the dissolve to move smoothly from scene to scene and, sometimes, to indicate a passage of time.

The *super,* or *superimposition,* is the blending together of two scenes. Television often uses this device to show dream scenes. One camera shows a close-up of the face of the sleeping person, and the other shows the scene about which the person is dreaming.

A *wipe* is a special effect in which one picture seems to push another picture off the screen. A wipe stopped halfway is called a *split screen.* TV productions use the split-screen technique to show scenes from two different places at the same time. Other wipes include the *circle* and the *diamond,* in which the second picture appears on the screen as an expanding circle or diamond.

The *matting,* or *keying,* technique is used to show titles and other objects over a scene. The letters of the titles come from a title card, title slide, or *caption generator* (electronic letter-making machine). The picture on which the letters appear comes from a studio camera, or film or tape.

The switcher also enables television broadcasters to *cut* (switch instantly) from the programme to filmed commercials, and back again.

The sound inputs of a TV programme are controlled by an instrument called an *audio console,* operated by an *audio engineer.* The audio engineer pushes buttons and moves levers to choose and mix together various audio inputs. A scene of two people sitting in a car might require the audio engineer to mix the sounds of the people's conversation with recorded sounds of the car engine, outside traffic, and background music. The audio engineer also controls the volume of sounds.

Taping the programme. Broadcasters usually record live programmes on videotape at the same time as they broadcast them. This allows them to rerun all or parts of a show at a later time. For example, videotaped highlights of a live broadcast of a speech by a national leader are often shown later on newscasts. Videotapes of live sports events allow sportscasters to rerun and analyse key moments immediately after they happen. This process is called *instant replay.*

Master control is the electronic nerve centre of a television station. Much of the electronic equipment that helps create television pictures is located there. A programme goes from master control by cable or microwave to the transmitter. Then, the transmitter sends it on its way to the viewers. Master control also has equipment for switching from programme to programme. The programmes may include some that originate outside the station, for example at network headquarters or at a remote location.

Other production methods

A television production can differ from the method just described in four chief ways. (1) Television producers put some programmes together piecemeal rather than straight through. (2) They shoot many programmes on film or videotape rather than with TV cameras. (3) They record many programmes for broadcast later instead of broadcasting them live. (4) They create programmes in locations away from studios. Such programmes are called *outside broadcasts* (OB's).

The piecemeal approach involves recording a program on videotape or film scene-by-scene with *stopdowns* (stops) between scenes. Each recorded scene is called a *take.* After each take, directors can play back the tape or film and judge its merits. If they like the take, they go on to another one. If they do not like it, they can call for a *retake* (shoot the scene over again). The piecemeal approach also allows directors to shoot scenes out of order. If, for example, the first and last scenes of a TV play happen in the same location, the director may shoot them one right after the other. Upon completion, film or tape editors splice all the scenes together in their proper order to create a continuous story.

Filming and taping programmes. Cameras that use film or videotape can be carried around and operated more easily than can television cameras. As a result, many TV producers use film or video cameras to create programmes that take place at several locations. For example, television news programmes, which report on widely scattered events, use film or videotape, as do programmes shot at faraway locations. In addition, film studios create some entertainment programmes with film cameras (see **Film industry** [How films are made]).

After camera operators film a programme, broadcasters transmit it from a telecine unit. For technical information, see *Telecine* later in this article.

Prerecorded broadcasts include nearly all entertainment programmes. These are produced straight through in the TV studio and recorded on videotape for broadcast later. The videotape machine stands in or near a special part of the television studio called *master control.* The director reviews the finished tape, and tape editors correct any major errors. Then, the tape is stored until the time the programme is scheduled for broadcasting. For technical information on videotape, see *Videotape recording* later in this article.

Outside broadcasts. Almost all outside broadcasts, are broadcast live. They include coverage of sports events and political conferences. Producers of these programmes use standard television cameras. But they also use cameras small enough to be carried around. These *hand-held cameras* help TV crews cover the huge area of a sports field or conference hall. Broadcasters park a *control vehicle* near the place of the broadcast. This vehicle contains control room and master control equipment needed to create TV signals. The signals travel by microwave or wire from the vehicle to the transmitter.

Television around the world

The popularity of television has created a huge television industry, particularly in industrial countries such as Australia, the United Kingdom, and the United States. In such countries, television broadcasting plays a major part in the lives of nearly all the people.

Australia. There are five television networks in Australia. The largest is the Australian Broadcasting Corporation (ABC). It is responsible for the national, noncommercial television service. There are over 500 transmitters and translators in the ABC network and in 1993, a second television service began broadcasting throughout Southeast Asia. Commercial television operates through three networks and is carried by more than 150 stations in all states. The Special Broadcasting Service (SBS) operates a multicultural service in all state capitals and is expanding to regional centres. It broadcasts in English and also in foreign languages with English subtitles.

Egypt. The Egyptian television industry has five channels. In 1990, the first Egyptian satellite space channel was broadcast via the Arab satellite *Arabsat* for transmission throughout the Arab world, Africa, and Europe.

India. The Indian television service, Doordarshan, is a department of the government. It reaches about 82 per cent of the country's population and carries commercial advertising. In 1992, the government announced that it would give broadcasting time to private companies on a second state channel broadcast to major Indian cities. Of the 523 TV transmitters in the network, 502 are linked through the Indian National Satellite system *(INSAT)*. A satellite based educational channel (ETV) broadcasts such programmes as First School Television and syllabus oriented programmes for higher education. The Indian government provides and maintains television sets in most community centres. In 1991, Doordarshan began experimental telecasts of both Houses of Parliament. In 1993, Doordarshan created five new television channels.

Indonesia has 10 television stations, with more than 240 transmitters sited in provincial districts to relay national programmes. The country had more than 8,900,000 television sets in 1989. In addition, there are about 54,000 public television sets in rural villages.

Ireland. Radio Telefís Éireann (RTE) is responsible for television broadcasts in the Republic of Ireland. Some of its broadcasts are in Irish, but most of its programmes are in English. There are two channels, RTE-1 and Network 2. A law passed in 1989 allowed for the setting up of a new commercial TV station.

About half of RTE's television broadcasts are imported programmes. RTE broadcasts more than 100 hours of television programmes each week. The Irish government appoints the nine members of the RTE authority.

Malaysia has three television channels. Two of these are administered by RTM (Radio and Television Malaysia). The third channel, TV3, is run by a private company. RTM also broadcasts some local programmes in Sarawak and Sabah. The minister of information controls and monitors all broadcasting, under the 1987 Broadcasting Act.

New Zealand. Television broadcasting in New Zealand is operated by the state-owned Television New Zealand Limited and a national private television service TV3. Television New Zealand Limited replaced the former Broadcasting Corporation of New Zealand in 1988. It is responsible for the production of programmes for the two TV networks. In 1991, a local television service for the Canterbury region began transmission.

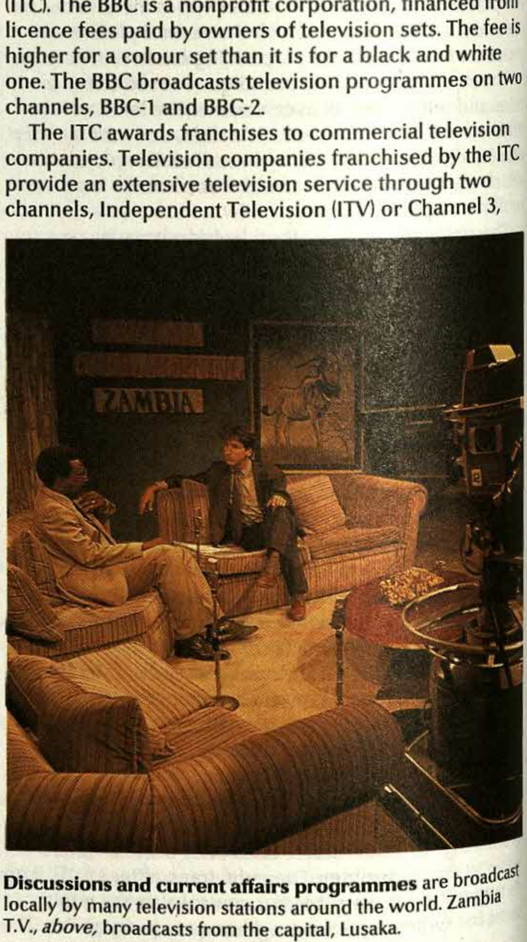
Philippines. Five major television networks broadcast throughout the islands with 19 carrier and seven relay stations. In 1992, the Congress approved legislation providing for the creation of a public television network, the People's Television Network (PTV4).

Singapore has three TV channels. Two carry programmes in the four official languages of Singapore. The third channel broadcasts mainly in English.

South Africa. Television broadcasting in South Africa is controlled by the South African Broadcasting Corporation (SABC). The SABC is licensed by the government and receives its funding through commercial advertisements. The SABC offers its viewers four television services in seven languages. TV1 and TV4 broadcast in English and Afrikaans, TV2 in Zulu and Xhosa, and TV3 in South Sotho, North Sotho, and Tswana.

United Kingdom. Almost all broadcasting in the UK is controlled by the British Broadcasting Corporation (BBC) or by the Independent Television Commission (ITC). The BBC is a nonprofit corporation, financed from licence fees paid by owners of television sets. The fee is higher for a colour set than it is for a black and white one. The BBC broadcasts television programmes on two channels, BBC-1 and BBC-2.

The ITC awards franchises to commercial television companies. Television companies franchised by the ITC provide an extensive television service through two channels, Independent Television (ITV) or Channel 3,



Discussions and current affairs programmes are broadcast locally by many television stations around the world. Zambia T.V., *above,* broadcasts from the capital, Lusaka.

and Channel Four. A Welsh version of Channel Four is Sianel Pedwar Cymru (S4C).

In 1993, there were 16 independent regional UK television companies. From 1994, some of these companies merged. Each company makes some programmes for its local audience. But during peak viewing hours, most of the companies show the same programmes. There is only one kind of programme that the companies are obliged to broadcast, the Independent Television News (ITN) programmes. The ITN is jointly owned and financed by the ITV companies.

United States. Television broadcasting in the United States is regulated by the Federal Communications Commission (FCC). The FCC is a federal government agency. It issues broadcasting licences to stations and assigns the frequencies on which the stations must broadcast. The FCC also sets standards for broadcasters and requires them to give equal time to all legally qualified candidates for public office. Together with the Federal Trade Commission (FTC), it evaluates truthfulness in television advertising.

In 1946, there were only 6 television stations in the United States. In 1993, the country had 1,505 stations. About three-quarters of all commercial television stations in the United States are *affiliates* of one of the four major national networks. That is, they agree to carry programmes provided by these networks. The major national television networks are those of the American Broadcasting Companies (ABC), CBS Inc., the National Broadcasting Company (NBC), and Fox Inc. A major television news provider is the Cable News Network (CNN).

Local commercial stations in the United States are supposed to show a variety of programmes, including programmes of local interest, during *prime time* (the evening hours, when television programmes draw the largest audiences). The amount of network programming they carry is limited by the FCC, but much nonnetwork programming consists of old feature films, talk shows, game shows, and reruns of old network shows. These programmes are *syndicated*—that is, sold to the stations by independent organizations. This is cheaper than the stations themselves producing new programmes.

Television programmes made in the United States are sold all over the world, and in many countries US-made programmes fill a substantial amount of viewing time.

Audience research. The TV executives who choose network programmes know that famous entertainers and championship sports contests usually attract large audiences. But these executives cannot be certain how many viewers other shows are likely to attract. They may be helped in choosing programmes by specialists in *audience research.* Such specialists collect data about people's interests and the kinds of programmes they like to watch. These specialists also gather the responses of audiences that are invited to view special "pilot" episodes of new programmes. Such research has limited success in predicting a programme's popularity for various reasons. For example, an audience's response to a single exposure to a programme might differ from its response to a series. As a result, programme planners must ultimately rely on their own intuition or "educated guesses" in choosing programmes.

Leading countries in number of TV sets

Country	Number of sets	Sets per 1,000 people
United States	201,000,000	814
Soviet Union	92,400,000	323
Japan	75,000,000	610
Germany	43,700,000	555
Brazil	30,000,000	204
China	30,000,000	27
United Kingdom	24,800,000	434
Italy	24,200,000	423
France	22,400,000	400
Canada	16,500,000	626

Figures are for 1989, prior to the breakup of the Soviet Union. Source: *Statistical Yearbook 1991,* UNESCO.

The success of a programme is measured in ratings and share. *Ratings* measure the percentage of all *TV homes* (homes that have television sets) that are tuned to a particular programme. *Share* measures the percentage of TV homes with a set switched on that are tuned to a particular programme. A national audience measurement service provides television stations and advertisers with information about ratings and share and with *demographic* data about audiences. Demographic data describe the makeup of an audience in terms of sex, age, income, education, and other features.

In the United States, a national audience survey typically consists of about 3,000 households that are paid a small fee for participating. The viewing habits in these households supposedly reflect the habits of the entire nation. Programme planners may cancel a programme that receives low ratings, often after only a few shows. The most advanced device to measure a TV audience is the "people meter," which resembles a TV remote-control unit. Family members each press an assigned key on the meter to indicate who is watching TV. In this way, the people meter registers the age and sex of a programme's viewers for advertisers.

Television awards are presented each year by a number of organizations. The best-known awards, the *Emmys,* are given by the United States Academy of Television Arts and Sciences and by the U.S. National Academy of Television Arts and Sciences. The two academies recognize achievements of the preceding year in various fields of the TV industry.

The British Academy of Film and Television Arts (BAFTA) presents a number of annual awards for programmes, actors, personalities, and production personnel working in the television industry. These include awards for artistic and technical achievement, music, and animation. There are awards for the best drama, the best light entertainment, the best factual series, the best children's programme, and the best outside broadcast coverage. There are also special awards for the best arts programmes, for factual TV, and for outstanding creative contributions to television. Other UK television awards include the Broadcasting Press Guild awards, and the Royal Television Society awards.

International television awards include the Prix Italia and the Montreux Golden Rose. Television programme makers from many countries submit programmes for judging for these awards.

Effects of television

In many countries, television ranks as a major influence on people's lives. It affects the way people spend their time, and what and how they learn. TV also affects politics, the other media, and sport. Some authorities believe that TV has an even greater influence on young people than on adults.

Effects on leisure time. A typical American or European adult spends more time watching TV than doing anything else except sleeping and working. Watching television ranks as the most time-consuming leisure activity among adults. It takes time away from other activities, such as reading, conversation, social gatherings, and exercise.

Effects on learning. Television contributes greatly to what home viewers learn. It benefits people by widening their experience. On the other hand, TV also may contribute to harmful impressions of the world.

Enriched experience. No communication system has ever provided so many people with as wide a range of new experiences as television has. Without leaving their homes, TV viewers can watch government officials perform important functions, and see how people in far-off lands look and live. Television takes viewers to deserts, jungles, and the sea floor. A TV viewer can see how a famous actor performs the role of Hamlet, and how top comedians draw laughter. Television gives its viewers a glimpse of real-life tragedy, as when it covers the victims of war, natural disasters, and poverty. It also captures moments of great triumph, such as when astronauts first set foot on the moon. However, some authorities question how much specific information viewers remember from watching television.

Harmful impressions. Many social scientists believe that people are likely to form two negative impressions from watching a lot of television. One of these impressions is that many people are better off than they are. The other is that the world is an unfriendly place, filled with untrustworthy people and risky circumstances.

Television programmes often show people who lead more glamorous lives and have more material possessions than most viewers. In addition, TV commercials constantly urge viewers to buy various goods. Many sociologists believe that as a result, the material expectations of TV viewers are raised, sometimes to an unrealistic level. One harmful effect results when people fail to achieve the success they see on TV and become dissatisfied or bitter.

The violent, crime-filled world shown on TV may contribute to an impression of an evil world. Studies indicate that people who watch a great deal of television are more likely to hold fearful or negative views of the world than those who watch less TV. However, some researchers argue that people who watch a lot of television already hold such views.

Effects on institutions. Television has brought about major changes in politics, films and radio, and sport.

Effects on politics. Every election year, thousands of political candidates use television in their campaigns. They appear on TV to urge voters to support them. They also appear in debates with other candidates and answer interviewers' questions about their views. Television plays its greatest role in national elections. Before TV, political party leaders tried to make personal appearances and speeches in as many cities as possible. Today, they reach more voters through a single television appearance than through all the in-person campaigning they do.

In some countries, such as the United States, politicians can buy TV time for a *spot announcement.* This is a political message lasting 10 to 90 seconds. In other countries, including the United Kingdom, such advertisements are illegal. Instead, broadcasting authorities allow the main political parties some free television time to present their policies and points of view.

Television does much to promote interest in politics and political issues. But political coverage on TV also draws criticism. Critics say that news coverage and interviews are too short to allow politicians to discuss issues. Instead, politicians use the time to present oversimplified statements to win support or attack their opponents. Such statements are often called *sound bites.* Critics also claim that, because television time in countries such as the United States is so expensive, TV campaigning gives unfair advantage to the political parties with the most money. Another complaint about television campaigning is that it leads to the "selling" of politics through advertising methods similar to those used to sell products.

Films and radio. From the 1920's to the 1940's, films and radio were the chief forms of entertainment for millions of people. Many people went to the cinema at least once a week. They listened to comedies, dramas, and other entertainment programmes on the radio almost every night. The rise of TV in the 1950's caused a sharp drop in cinema attendance in some countries. Radio entertainment changed completely after TV became a part of Western life. Many radio entertainment shows went off the air, and recorded music became the chief kind of radio programming.

National magazines also suffered after the arrival of television. Some popular magazines that had circulations of many millions went out of business when advertisers shifted huge amounts of money to television.

Professional sport has long attracted millions of spectators yearly. But many more millions now watch sports on TV. Television networks and stations pay huge amounts of money for the right to televise sports events. Television also helps increase the popularity of sports. For example, in the United Kingdom, the popularity of snooker has soared largely because of television. Some opponents of television coverage of sport argue that minority sports suffer a loss of interest when big-name sports dominate.

Effects on young people. There is little agreement about how television affects young people. Parents have long been concerned about the amount of time young people spend watching TV. Studies have linked watching a lot of television with poor performance in school. However, these studies do not prove that TV viewing actually causes students to perform poorly. Watching television may simply be an activity preferred by young people who do poorly in school. Other studies suggest that television encourages aggressive behaviour by showing so much violence.

A person looking directly at a scene sees the entire view all at once. But television cannot send a picture of an entire scene all at once. It can send only one tiny part of the picture after another until it has sent the complete picture. A TV camera divides a picture into several hundred thousand tiny parts by a process called *scanning.* As the camera scans the picture, it creates electronic signals from each part of the picture.

A TV set uses these signals in re-creating the picture on its screen. The scanning process puts the picture back together piece by piece. A person watching TV cannot see that this is happening. The process works so quickly that the viewer sees only a complete picture.

Sending television pictures and sounds involves three basic steps. (1) The light and sound waves from the scene being televised must be changed into electronic signals. (2) These signals must be transmitted to the television receiver. (3) The receiver must unscramble the signals and change them back into copies of the light and sound waves that came from the original scene.

Creating television signals

A television signal begins when light from the scene being televised enters a television camera. The camera changes the light into electronic signals. At the same time, a microphone picks up the sounds from the scene and changes them into electronic signals. Television engineers call the signals from a camera *video* and the signals from a microphone *audio.*

This section describes how a TV camera creates video signals. It also explains how video signals are produced by *telecine* (television film) and videotape. TV audio signals are created in the same way as radio signals. For information on this process, see **Radio.**

The video signals broadcast by most TV stations are *composite colour signals.* These signals produce a colour picture when received on a colour television set, and they produce a black-and-white picture on a black-and-white set.

Colour TV uses the three *primary colours in light*—red, blue, and green—to produce full-colour pictures. The proper mixture of these three colours can produce any colour of light. For example, a mixture of red and green light produces yellow light. Equal amounts of red, blue, and green light together produce white light.

The television camera. In producing a composite colour signal, the TV camera must (1) capture the image of the scene being televised; (2) create video signals from the image; and (3) encode the colour signals for transmission. To perform these tasks, a TV camera uses a lens, a system of mirrors and filters, image sensors, and complex electronic circuits. Some of the electronic circuits used by the cameras are located elsewhere and connected to the cameras by wires.

Capturing the image. The lens gathers the *image* (picture) of the scene in front of the camera. Like the lenses in other cameras and the human eye, the TV lens *focuses* (collects and bends) the light from the scene and forms a sharp image. This image contains all the colours of the scene. However, in order to produce colour signals, the camera must split the full-colour image into three separate images—one for each primary colour.

Most TV cameras use two *dichroic mirrors* to split the image into the primary colours. The first mirror reflects the blue image and allows red and green light to pass through it. The second mirror reflects the red image, leaving only the green image, which passes on to a camera tube. Other mirrors reflect the red and blue images on to separate image sensor. In many cameras, this colour separation is done by colour filters and prisms contained in a small compartment called the *prism block.*

Creating the video signals. An image sensor changes the light image into video signals. A black-and-white camera has only one sensor. Most high-quality colour cameras have three such sensors. These sensors create a separate video signal for each of the three primary colours. Many small, lower-quality, portable cameras are equipped with a single sensor. This sensor has many thin red, blue, and green *filter stripes* on its surface. The stripes divide the light into the three primary colours, and the sensor then converts each of the colours into a separate video signal.

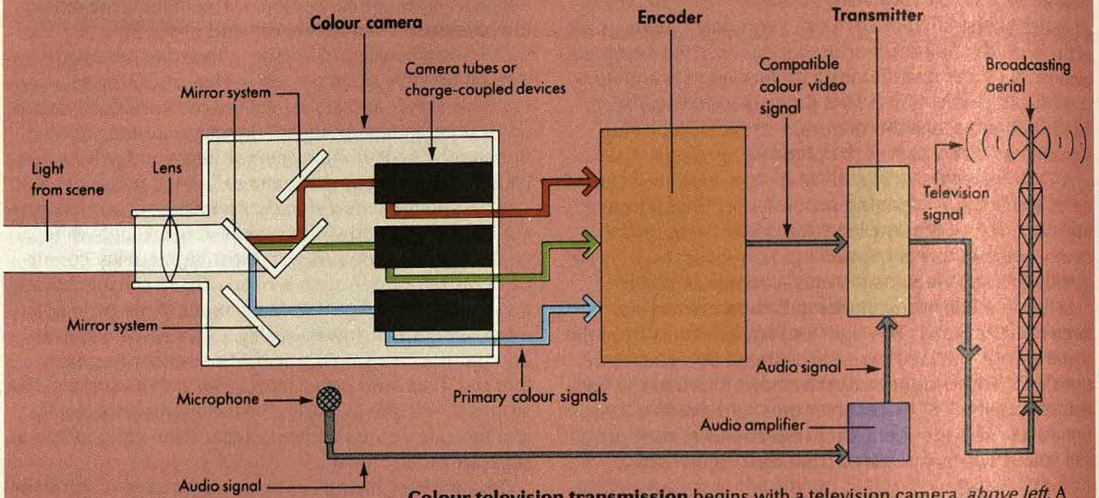
Two types of image sensors may be used in television cameras. *Tube cameras* contain improved versions of a vacuum tube called a *vidicon. Solid-state cameras* contain electronic sensing mechanisms called *charge-coupled devices,* or CCD's. Solid-state cameras are smaller, lighter, and more reliable than tube cameras. This section describes the working of one sensor in cameras that have three.

A vidicon tube has a glass *faceplate* at its front end. At the back of the faceplate is a transparent coating called the *signal plate.* A second plate, called the *target,* lies behind the signal plate. The target consists of a layer of *photoconductive material* that conducts electricity when exposed to light. At the rear of the tube is a device called an *electron gun.*

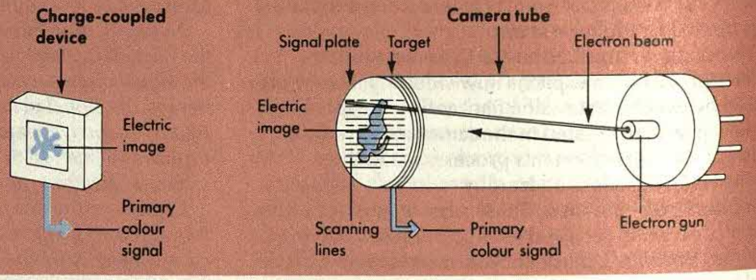
Light from the image reaches the target after passing through the faceplate and the signal plate. The light causes negatively charged particles called *electrons* from the photoconductive material to move toward the signal plate. This movement leaves the back of the target with a positive electric charge. The strength of the positive charge on any area of the target corresponds to the brightness of the light shining on that area. The camera tube thus changes the light image gathered by the lens into an identical electric image of positive charges on the back of the target.

The electron gun shoots a beam of electrons across the back of the target. The beam moves across the target in an orderly pattern called a *scanning pattern.* As the beam moves across the target, it strikes areas with different amounts of positive charge. Areas of the target that have the strongest charge attract the most electrons from the beam. This occurs because particles of unlike electric charge attract each other. Other areas of the target attract fewer electrons. The electrons from the beam move through the target and cause an electric current to flow in the signal plate. The strength of this current changes from moment to moment, depending on whether the beam is striking a bright or dim part of the image. This changing current is used to produce a changing voltage. This is the video signal from that camera tube.

How colour television is transmitted



Colour television transmission begins with a television camera, *above left.* A mirror system breaks light from a scene into the three primary colours of light—red, blue, and green. At the same time, a microphone changes sounds into *audio* signals. Camera tubes or charge-coupled devices then convert the coloured light images into electronic *video* signals. These signals go to the encoder, which produces a composite colour signal for transmission. The transmitter combines the audio and video signals for broadcast from the aerial.



A primary colour signal is produced by a charge-coupled device, *right,* or a camera tube, *far right.* Each translates the light image that strikes its surface into an identical pattern of electric charges. The scanning process then translates the charges into an electric current that becomes the video signal.

A charge-coupled device is a silicon chip with tiny, square photoconductive *elements* (parts) arranged on its surface. Light falling on an element (also called a *pixel*) causes electrons to flow into the element's *capacitor,* a device that stores an electrical charge. As more light falls on the element, more electrical charge accumulates in the capacitor. The CCD thus changes the light coming through the camera lens into an identical electric image. The CCD then reads out the image by releasing the charge stored in each capacitor to cause an electric current to flow. This current is the video signal from that CCD. The CCD releases the capacitor charges according to the scanning pattern.

Most television systems use *interlaced scanning.* This pattern starts at the top of the picture and scans the odd-numbered lines from left to right. After it reaches the bottom, it returns to the top and scans the even-numbered lines.

The scanning pattern of TV cameras in many countries uses the *phase alternator line (PAL) system,* made up of 625 lines. This produces 50 half images per second, forming 25 complete images per second through interlace scanning.

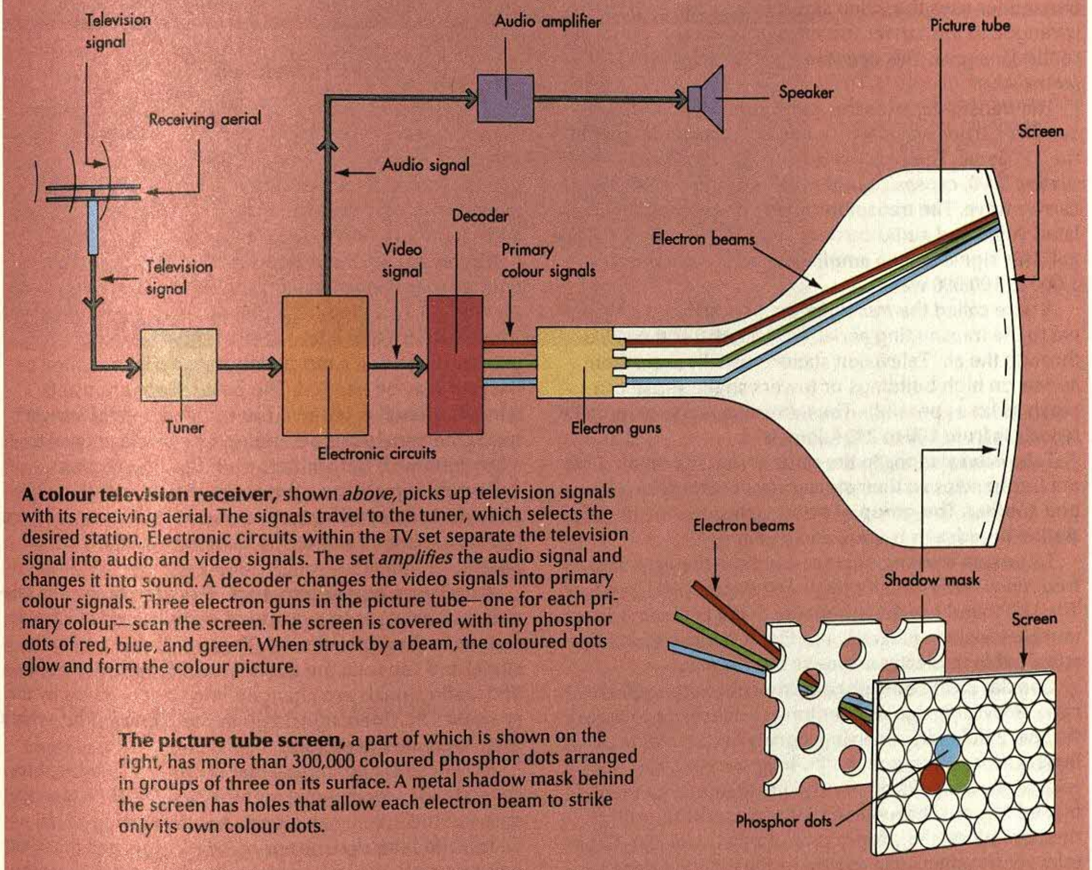
In the National Television Standards Commission (NTSC) system, developed in the United States, the picture is made up of 525 lines, with 30 complete images per second. The French system, Système Couleur (SECAM), has 625 or 819 lines, with 25 images per second.

In any system, each of the three image sensors converts its particular primary colour to a video signal by means of the scanning process. Wires carry the signals to electronic circuits in the camera that *amplify* (strengthen) them. The three signals then go to the *encoder.*

Encoding the colour signals. At the encoder, the three video signals are combined with other signals to produce a compatible colour signal. The first step in this process involves combining the three video signals into two colour-coded signals and a black-and-white signal. The two colour-coded signals are called *chrominance signals* and the black-and-white signal is called a *luminance signal.* In the encoder, a circuit called the *matrix* performs this function.

The encoder then combines the chrominance and luminance signals and, in the process, adds a *colour burst* and *synchronization signals.* The colour burst enables a colour TV set to separate the colour information in the

How colour television is received



A colour television receiver, shown *above,* picks up television signals with its receiving aerial. The signals travel to the tuner, which selects the desired station. Electronic circuits within the TV set separate the television signal into audio and video signals. The set *amplifies* the audio signal and changes it into sound. A decoder changes the video signals into primary colour signals. Three electron guns in the picture tube—one for each primary colour—scan the screen. The screen is covered with tiny phosphor dots of red, blue, and green. When struck by a beam, the coloured dots glow and form the colour picture.

The picture tube screen, a part of which is shown on the right, has more than 300,000 coloured phosphor dots arranged in groups of three on its surface. A metal shadow mask behind the screen has holes that allow each electron beam to strike only its own colour dots.

chrominance signals. This information, along with the luminance signal, produces a full-colour picture on the TV screen. A black-and-white TV set uses only the luminance signal. The synchronization signals lock the receiving set into the same scanning pattern as that used by the camera.

Telecine is equipment that transfers the images from films or slides into TV signals. Telecine uses a combination of film and slide projectors and a single television camera called a *telecine camera* to create such signals. A typical telecine unit, sometimes called a *film chain,* consists of two film projectors, a slide projector, a *multiplexer,* and a telecine camera. The *multiplexer* is a system of mirrors that directs the images from the films or slides into the telecine camera. The camera then converts these images into video signals.

Videotape recording stores television pictures and sound as magnetic impulses on tape. The video signals are usually recorded as *diagonal* (slanted) tracks in the centre of the tape, and sound and control signals are recorded along the tape's edge. Unlike film, which must be developed before showing, a videotape can be played back immediately.

Character generators and video paint boxes work like small computers to generate letters or pictures. TV productions use these graphics to create a variety of materials, including advertisements and weather maps.

Transmitting television signals

Most television signals are broadcast through the air. Engineers at a television station use a device called a transmitter to produce a TV signal from separate audio and video signals. The signal is then carried by wire to a transmitting aerial, and broadcast. The transmitted signal is called an *electromagnetic wave.* Such waves can travel through the air at the speed of light, about 300,000 kilometres per second. But the signal can be received clearly only up to a distance of about 250 kilometres. To send TV signals farther, other methods of transmitting the signal, such as coaxial cable and fibre-optic cable, microwaves, and satellites, must be used.

Broadcasting. Before a television signal is broadcast, the transmitter amplifies it and sends it to the transmitting aerial. A television signal needs a high frequency to carry the picture information through the air. The transmitter amplifies the signal to increase its range.

The transmitter combines the audio and video signals as electromagnetic waves in a process called *modula-*

tion. High-frequency electromagnetic waves, called *carrier waves,* are first generated by the transmitter. The transmitter uses the video signal to vary the *amplitude* (strength) of the carrier waves to produce the video part of the TV signal. This process is called *amplitude modulation* (AM).

The transmitter uses the audio signals to modulate another carrier wave, which becomes the audio part of the TV signal. The process used, called *frequency modulation* (FM), causes changes in the frequency of this carrier wave. The transmitter then combines the modulated video and audio carrier waves to form the TV signal. This signal is then amplified, usually to a power of 1,000 to 100,000 watts.

A wire called the *transmission line* carries the TV signal to the transmitting aerial, which radiates the signal through the air. Television stations usually erect their aerials on high buildings or towers so the signal can reach as far as possible. The maximum range of most TV signals is from 100 to 250 kilometres.

Television stations in the same area transmit on different frequencies so their signals do not interfere with one another. The group of frequencies over which one station broadcasts is known as a *channel.*

Television stations broadcast in both the *very high frequency* (VHF) and *ultrahigh frequency* (UHF) bands. The UHF band has the advantage that it accommodates more television channels, and that broadcasts are less susceptible to electromagnetic interference.

Coaxial cable and fibre-optic cable are used to carry television signals over long distances or to areas that have difficulty receiving signals because of problems such as intervening hills. In some countries, the television networks often send programmes to their affiliated stations through coaxial cables. These stations then broadcast the programmes to their viewers. Cable television systems use coaxial or fibre-optic cables to carry signals to the homes of subscribers. See **Coaxial cable; Fibre optics.**

Microwaves are electromagnetic waves, similar to television signals. In some countries, tall relay towers spaced about 50 kilometres apart carry programmes from the television networks to affiliated stations on these waves. Equipment in a tower automatically receives, amplifies, and then retransmits the microwave signal to the next tower. The affiliated stations change the microwave signals back into TV signals.

Satellites carry television signals between stations where cable links or microwave towers cannot be built. For example, satellites relay television signals across oceans. Satellites work like relay towers in space. They receive coded television signals from an earth station, amplify them, and send them on to another earth station. The stations may be thousands of kilometres apart.

This type of satellite, which may also carry other communication channels, is mainly used by television broadcasting companies. Such satellites are used to link up with correspondents overseas during news programmes. Correspondents sometimes use portable satellite links with dish aerials to transmit live reports from remote locations.

Another type of satellite used by television stations is a direct broadcast satellite. Such satellites send TV programmes directly to individual homes. A dish aerial, decoder, and special tuner are required to receive programmes.

Receiving television signals

The television signal from a transmitter is fed into a home television set through a *receiving aerial.* The set uses the signal to make copies of the pictures and sounds from the televised scene. In reproducing the television programme, a TV set uses a tuner, amplifiers and separators, and a picture tube.

Receiving aerial. A good aerial collects a strong enough television signal for the receiver to produce a picture. A simple indoor aerial picks up a strong enough signal within a few kilometres of the transmitter. At greater distances, a more elaborate aerial mounted on the roof may be needed. The best reception results when the aerial is pointed toward the desired transmitter. Some aerials can be rotated by remote control to align them with transmitters in different directions.

Tuner. Signals from the aerial are fed into the tuner of a television set. The tuner selects only the signal from the station the viewer wants to receive. It shuts out all others.

Amplifiers and separators. From the tuner, the television signal goes to a group of complicated electronic circuits in the television set. These circuits amplify the signal and separate the audio and video portions of it. The audio signals are changed into sound waves by the speaker. The video signals go to the *picture tube,* where they re-create the picture.

A colour set has circuits that use the colour burst to separate the video signal into the two chrominance signals and the luminance signal. Another group of circuits, called the *decoder* or *matrix,* transforms these signals into red, blue, and green signals that duplicate the signals from the three camera tubes.

The picture tube converts the video signals into patterns of light that reproduce the scene in front of the camera. One end of the picture tube is rectangular and nearly flat. This end forms the screen of the television set. Inside the set, the picture tube tapers to a narrow neck. The neck of a colour picture tube holds three electron guns—one each for the red, blue, and green signals. A black-and-white tube has only one electron gun.

Each electron gun in a colour picture tube shoots a separate beam of electrons at the screen. Each beam scans the screen just as the beam in each camera tube scanned its target. The synchronization signal, which is part of the video signal, ensures that the picture tube's scanning pattern follows exactly the pattern used by the camera. The beams must be in step with each other in order to produce a steady, undistorted picture.

The screen of most colour tubes is coated with more than 300,000 tiny phosphor dots. The dots are grouped in threes—one red, one blue, and one green. These dots glow with their respective colour when struck by an electron beam. A metal plate perforated with thousands of tiny holes lies about 13 millimetres behind the screen. This plate is called the *shadow mask.* Its holes keep the beams from hitting any colour dots but their own.

High-definition television (HDTV) produces a super-sharp image, as shown on the left side of the photograph. The image on the right side was produced by a standard television set.

The amount of light given off by the dots depends on the beam's strength at the instant it strikes them. Since the beam's strength is controlled by the video signal, originally produced by the camera, the dots are bright where the scene is bright and dark where the scene is dark. When the TV set shows a colour programme, the coloured dots on the screen blend together in the viewer's mind to produce all the colours in the original scene (see **Eye** [How we see]). The dots appear to produce only differing amounts of white light for a black-and-white programme.

Developments in television technology

Improved TV technology during the 1980's and 1990's resulted in sharper pictures. The quality of the picture depends on the number of scanning lines used to create the image and on the amount of detail in each scanning line. To produce sharper pictures, television signals must carry more information than they now do.

Digital television represents one of the biggest changes in television since the introduction of colour in the 1950's. Digital systems convert television signals into sequences of 1's and 0's—that is, the same numerical code used by computers. Digital systems provide stronger and more reliable signals. Such signals are less likely to be disrupted by electrical interference from appliances and thunderstorms or by reflections from tall buildings and aircraft.

Digital systems also improve TV pictures by making it possible for television signals to carry more information. Digital systems use a technique called *data compression* that removes unnecessary information from the signal. For example, a frame of a film or a television signal usually resembles the one before it. Digital systems take advantage of *digital memory* in the receiver to avoid retransmitting the parts of the picture that remain the same. The system can then fit higher-quality signals into existing channels. Digital technology makes it possible to improve today's TV systems and to create new systems for the future.

High-definition television (HDTV) produces super-sharp images. HDTV employs over 1,000 scanning lines, each of which carries a greater amount of detail than do today's lines. Other improvements that may be offered by HDTV include wider screens, digital transmission of video and sound, and *progressive scanning.* This scanning pattern offers greater clarity than interlaced scanning because it scans all the lines every time. Limited HDTV transmissions began in Japan in 1989. The television industry hoped to bring HDTV to U.S. and Canadian viewers in the late 1990's. HDTV was scheduled to begin in Europe in the late 1990's or early 2000's.

Future improvements. Millions of homes now receive TV signals from direct-broadcast satellites (DBS). DBS may reach even more households as home satellite aerials become smaller. Engineers hope to reduce the size of home aerials from about 3 metres to less than 30 centimetres across.

Another area of research involves the development of flat *liquid crystal display* (LCD) television screens. These lightweight, energy-saving screens could hang on a wall like a picture.

History

Early development. Many scientists contributed to the development of television, and no one person can be called its inventor. Television became possible in the 1800's, when people learned how to send communication signals through the air as electromagnetic waves. This process is called *radio communication.* For details on its development, see **Radio** (History).

The first radio operators sent code signals through the air. By the early 1900's, operators could transmit words. Meanwhile, many scientists had conducted experiments involving the transmission of pictures. As early as 1884, Paul Gottlieb Nipkow of Germany had invented a scanning device that sent pictures short distances. His system worked mechanically, rather than electronically as television does. In 1922, Philo T. Farnsworth of the United States developed an electronic scanning system. In 1926, John Logie Baird, a Scottish engineer, gave the first public demonstration of a mechanical television system. Vladimir K. Zworykin, a Russian-born American scientist, invented the *iconoscope* and the *kinescope* in 1923. The iconoscope was the first television camera tube suitable for broadcasting. The kinescope is the picture tube used in TV receivers. Zworykin demonstrated the first completely electronic, practical television system in 1929.

The start of broadcasting. Many experimental television broadcasts took place in the late 1920's and the 1930's. The BBC in the United Kingdom and CBS and NBC in the United States were leaders in experimental television broadcasts. The BBC started the world's first public television service in 1936, broadcasting from Alexandra Palace, in London.

In 1936, the Radio Corporation of America (later RCA Corporation), which owned NBC, installed television receivers in 150 homes in the New York City area. NBC's New York station began experimental television broadcasts to these homes. A cartoon of Felix the Cat was its first programme. NBC established the first regular TV broadcasts in the United States in 1939.

Television broadcasting resumed in the United Kingdom and the United States after World War II (1939-1945). At first, broadcasts were experimental and only a few people had TV sets. But by 1951, the Americans had extended television broadcasts from coast to coast. People were fascinated by television. During the 1950's, there was a huge growth in the use of television in Western countries.

The United Kingdom had just one TV service until 1955, when the commercial Independent Television (ITV) network began operating. Australia opened its first national and commercial stations, in Sydney and Melbourne, in 1956. Irish television began in 1961.

Early programmes. Comedy shows and westerns were popular in the 1950's. Quiz shows, with big money prizes, became favourites on commercial stations. Drama serials, such as the UK's "Coronation Street", also attracted millions of viewers. "Coronation Street" began in 1960, and was still attracting huge weekly audiences in the 1990's.

By the 1980's, crime series had replaced Westerns as the most popular dramas. Many television stations featured talk shows, quizzes, comedies, and sports programmes.

The 1960's. Although popular entertainment remained the major part of television programming during the 1960's, TV planners also increasingly covered events such as political rallies, state funerals, and royal weddings. The series of television debates in 1960 between U.S. presidential candidates John F. Kennedy and Richard Nixon was seen as a milestone in television broadcasting. Politicians quickly realized the importance of television in presenting themselves and their political messages to voters.

Television also regularly brought viewers scenes of war, natural disaster, and famine. The Vietnam War of the 1960's and 1970's was sometimes called "the first war to be fought on television." Civil rights protests in the United States, Eastern Europe, and southern Africa also received TV coverage.

Technological advances made during the 1950's and 1960's helped improve the technical quality of television broadcasts. In TV's early days, most screens measured 18 or 25 centimetres diagonally. Today, 53- and 64-centimetre screens are common. In the 1970's, manufacturers introduced *projection television systems,* which beam programmes onto a screen as large as 2 metres measured diagonally. Other TV sets, small enough to fit in a pocket, have screens measuring about 7.5 centimetres diagonally. These sets use small cathode-ray tubes to produce the television pictures. In some models, the phosphorescent screen is viewed from the inside through a side window in the tube, allowing a more compact design. Liquid-crystal screens, similar to those used in portable computers, are now available, in both black-and-white and colour sets. Such screens give poorer pictures than those produced by cathode-ray tubes, but are more compact and require less power.

Improvements in broadcasting and receiving equip-

An experimental television broadcast of the late 1920's showed the comic strip character Felix the Cat.

News coverage of wars and natural disasters brings drama and tragedy into millions of homes.

Rock videos, which became popular in the 1980's, featured such performers as singer Michael Jackson.

ment provide much clearer pictures than were available in the past. In early days, all programmes were broadcast in black and white. Colour television began in many countries during the 1950's. Today, most programmes are broadcast in colour. More than 90 per cent of households in most industrial countries have a colour set.

At first, most television broadcasts were live productions or programmes made from film. The film took time to develop. Also, the equipment and techniques used produced pictures and sound of poor quality. Videotaping of programmes began in the mid-1950's, and became a major production method. Videotapes can be played back immediately after taping. They produce good quality pictures and sound, and allow flexibility in programme scheduling. Later, scientists developed equipment and techniques that improved the quality of filmed shows.

Early Bird, the first commercial communications satellite, was launched in 1965. Satellites made worldwide television broadcasting possible. Today, viewers can watch such events as the Olympic Games as they happen.

Recent developments. Television continues to be primarily a source of entertainment. But it also carries on its role of providing coverage of important events. For example, in 1973, U.S. networks cancelled many programmes to cover the Watergate hearings—a U.S. Senate investigation of charges of illegal practices during the 1972 presidential election (see **Watergate**).

In the early years of television, broadcasters generally avoided controversial themes, such as abortion, alcoholism, divorce, drug abuse, political satire, prejudice, and sex. They feared such themes might offend some viewers. But in the late 1960's, broadcasters found that they could deal with controversial themes without many complaints. "M*A*S*H," a popular U.S. situation comedy of the 1970's and early 1980's, satirized war. The highly successful "Neighbours," a soap opera produced in Australia, deals with family problems. In the United Kingdom, "EastEnders" deals with the problems of an inner-city community, including crime, difficult family relationships, and racism.

Many people believe, however, that television has gone too far in its presentation of controversial themes. The amount of violence and sex on TV has especially drawn a great deal of criticism. In the United Kingdom, a Broadcasting Standards Council was set up in 1988 to draw up codes of acceptability and decency, providing guidelines for programme makers.

In the late 1970's, broadcasters began to present an increasing number of made-for-TV movies, serialized dramas called *mini-series,* and other special programmes. One popular mini-series was "Roots," an eight-part drama tracing the history of an American black family from slavery to freedom. In the 1980's, Indian television showed a number of locally made drama series, including the popular "Buniyaad," which showed the life of an Indian family through seven decades.

During the 1980's, videocassette recorders for home use became widely available. Many viewers enjoyed renting or buying pretaped feature films and watching them at home. Also in the 1980's, satellites were increasingly used for relaying television programmes.

By the early 1990's, *high-definition television* (HDTV), which produces very sharp pictures and excellent sound, seemed to offer the next advance in TV technology. For more information, see the *Developments in television technology* section of this article.

Related articles in ***World Book*** include:

Biographies

Baird, John L.
De Forest, Lee
Farnsworth, Philo T.
Hertz, Heinrich R.
McLuhan, Marshall
Murrow, Edward R.
Zworykin, Vladimir K.

Equipment and physical principles

Aerial
Automatic frequency control
Coaxial cable
Electromagnetism
Electron gun
Electronics
Frequency modulation
Image orthicon
Microphone
Microwave
Radio
Satellite, Artificial
Speaker
Static
Tape recorder
Transistor
Ultrahigh frequency waves
Very high frequency waves
Video camera
Videodisc
Videotape recorder

Other related articles

Advertising
British Broadcasting Corporation
Copyright
Medicine (with pictures)

Outline

I. Uses of television
- A. Commercial television
- B. Public television
- C. Cable television
- D. Satellite broadcasting
- E. Closed-circuit television
- F. Video entertainment systems
- G. Televised information services

II. Producing television programmes
- A. Planning and preparation
- B. Putting a show on the air
- C. Other production methods

III. Television around the world
- A. Australia
- B. Egypt
- C. India
- D. Indonesia
- E. Ireland
- F. Malaysia
- G. New Zealand
- H. Philippines
- I. Singapore
- J. South Africa
- K. United Kingdom
- L. United States
- M. Audience research
- N. Television awards

IV. Effects of television
- A. Effects on leisure time
- B. Effects on learning
- C. Effects on institutions
- D. Effects on young people

V. How television works
- A. Creating television signals
- B. Transmitting television signals
- C. Receiving television signals
- D. Developments in television technology

VI. History

Questions

What is the role of electromagnetic waves in television?
What is a dissolve? A super? A wipe?
How did Vladimir K. Zworykin help develop TV?
How are television audience ratings measured?
What are the PAL and SECAM systems?
What are the methods of transmitting TV programmes?
What are some negative impressions that people may form from watching a lot of television?
On what does the quality of a television picture depend?
How have satellites changed television broadcasting?
What are some specialized uses of television?

Telex. See **Telegraph** (Faster and better service).

Telford, Thomas (1757-1834), a noted Scottish civil engineer, devised improved methods of road construction. The Telford method of using large flat stones for road foundations is named after him. Telford engineered bridges, canals, harbours, docks, and waterways. He built the Menai Strait suspension bridge which connects the Island of Anglesey and the mainland of Gwynedd County in Wales, and the Ellesmere Canal, connecting the Rivers Mersey, Severn, and Dee in England. He also engineered the Caledonian Canal in Scotland. He was born in Eskdale, Scotland.

Tell, William, was a legendary hero of Switzerland. He represents the spirit of the Swiss movement for independence from the Austrian Habsburgs in the 1300's. According to legend, Tell was the most skilled marksman in the whole *canton* (state) of Uri. The Austrian bailiff, Gessler, had ordered all Swiss to bow to a hat he had set up on a pole in the main square of Altdorf. Tell refused to bow, and was arrested. Gessler promised to let Tell go free if he could shoot an apple off his own son's head. Tell hit the apple and then said if he had hurt his son, he would have killed Gessler. Gessler had him seized and chained.

William Tell was a legendary Swiss patriot. The character is known for shooting an apple off his son's head with a crossbow.

While Tell was being taken across a lake in Gessler's boat, a storm broke. Gessler ordered Tell untied to help steer the boat safely to the shore. Tell escaped to the shore and shot an arrow through the tyrant's heart. This act led to a revolt by the Swiss, in which Tell played a leading role. This tale is the basis of Johann Friedrich Schiller's drama *William Tell* (1804). Gioacchino Rossini wrote the opera *William Tell* (1829).

Teller, Edward (1908-), an outstanding American atomic scientist, is often called the *father of the hydrogen bomb.* His work in nuclear physics led to the development of the H-bomb in 1952.

Teller was born on Jan. 15, 1908, in Budapest, Hungary. He received his doctor's degree in physics from the University of Leipzig, Germany, in 1932. He joined the wartime atomic bomb project in the U.S.A. in 1941. He worked with the Los Alamos (New Mexico) National Laboratory until 1952. Then he joined what is now the Lawrence Livermore Laboratory, a research facility at Livermore, California, dedicated to designing nuclear weapons. Teller also served as professor of physics at the University of California from 1953 to 1975. He was director of the Livermore laboratory from 1958 to 1960 and associate director from 1972 to 1975.

Tellurium is a chemical element with symbol Te. It is a semimetal. Pure tellurium is usually obtained as a by-product of copper refining. In nature, the element most often occurs in combination with such metals as copper, gold, lead, mercury, and silver. Tellurium is important in the manufacture of certain alloys and in semiconductor research. It serves as a curing agent for rubber and as a catalyst in petroleum refining. It is also used to colour glass and ceramics. The atomic number of tellurium is 52, and its atomic weight is 127.60. The crystalline form of tellurium melts at 449.8 °C and boils at 989.9 °C. Tellurium was discovered in 1782 by the Austrian chemist Franz Müller von Reichenstein.

Telstar. See **Satellite, Artificial; Telephone** (Telephone improvements).

Tempera. See **Painting** (Tempera; pictures).

Temperature is how hot or cold something is as measured on a particular scale. The concept of temperature is closely related to the flow of heat between two connected objects of different temperatures. Heat always flows from the hotter object to the cooler one.

Instruments that measure temperature are called *thermometers.* A scale marked on the thermometer indicates each level of "hotness." The two most common temperature scales used on thermometers are *Celsius* and *Fahrenheit.* Temperatures on all scales are based on the *International Temperature Scale of 1990* (see **Thermometer** [Temperature scales]).

Scientists often speak of *thermodynamic temperature,* a fundamental physical quality completely independent of the properties of a substance. The unit of thermodynamic temperature is the *kelvin,* indicated by *K.* This unit was agreed upon by scientists from many nations. All temperatures are based on their position above or below 273.16 K, a temperature called the *triple point of water.* At this temperature, water, ice, and water vapour all exist together. In common practice, a temperature is actually expressed in terms of its difference from the melting point of ice. Under one atmosphere of pressure, ice melts at a temperature 0.01 K lower than the triple point of water (see **Atmosphere**).

Temperature does not seem to have an upper limit. Scientists believe the temperature at the centre of the sun is about 15 million degrees Celsius. However, the interior of any star larger than the sun is probably much hotter. On the other hand, there does seem to be a lower limit to temperature. This theoretical limit, called *absolute zero,* has a value of −273.15° C. At this temperature, the molecules and atoms of a substance have the least possible energy.

Related articles in ***World Book*** include:

Absolute zero
Air
Boiling point
Bolometer
Celsius scale
Climate
Cryogenics
Freezing point
Heat
Melting point
Pyrometry
Sun (The sun's heat)
Weather

Temperature, Body. Body temperature is a measurement of the heat in an animal's body. The body of an animal generates heat by burning food. But the animal also loses heat to—or gains heat from—its environment.

Birds and mammals, including human beings, are *warm-blooded animals.* Their body temperature almost always stays fairly constant, regardless of the temperature of their environment. The body of a warm-blooded animal balances the amount of heat it exchanges with the environment with the amount it produces by burning food. Nearly all other animals are *cold-blooded animals.* Their body cannot balance this heat exchange so accurately. As a result, their body temperature tends to vary with the temperature of their environment.

When taken orally, the average body temperature of a healthy, resting adult human being is 37.0° C. Doctors consider a temperature within 0.5° C of this figure normal. A higher temperature may indicate a fever (see **Fever**). A lower temperature may be a sign of old age or of certain illnesses.

Warm-blooded animals make various physical and behavioural adjustments to regulate their heat exchange with the environment. In cold surroundings, they increase the production of body heat and decrease the amount of heat lost to the environment. In hot surroundings, they do just the opposite. A part of the brain called the *hypothalamus* controls these adjustments. Certain nerves in the skin and deep within the body send messages to the hypothalamus. The hypothalamus compares the temperatures of these areas with that of the brain. It triggers the necessary responses by nerves and glands to keep a normal body temperature.

Even with the various controls, the body temperature of a warm-blooded animal does not remain entirely constant. It changes slightly throughout the day. In a healthy human being, for example, the body temperature is lowest in the morning and then rises until late afternoon. It falls again during sleep. Strenuous activity can raise the body temperature. In cold surroundings, the temperature of the skin and limbs may drop far below the temperature deep within the body.

Each species of warm-blooded animal has its own normal body temperature. Each species also functions best when the temperature of its surroundings remains within a certain range. This range varies greatly from species to species, depending on such factors as the thickness of fur and the rate at which its body burns food. Some warm-blooded animals hibernate. During hibernation, their body temperature drops below normal. In fact, the body temperature of most hibernators drops almost to the temperature of their environment. See **Hibernation.**

Cold-blooded animals lack the precise temperature regulation abilities that characterize warm-blooded creatures. However, many cold-blooded animals can exercise some physical and behavioural control over body temperature. Reptiles, for example, can alter the amount of heat their body absorbs from the sun by changing their skin colour. Moreover, many reptiles alternately warm themselves in the sun and cool themselves in the shade, thereby maintaining a fairly constant body temperature throughout the day.

See also **Warm-blooded animal; Cold-blooded animal; Hypothermia.**

Temperature-humidity index, also called THI, is a scale of values that serves as an estimate to predict how comfortable people will feel in hot weather. The values of the scale depend on air temperature and *relative humidity*—that is, the actual moisture in the air compared with the most moisture the air could hold. They do not include the effects of wind and sunshine. However, the scale does help indicate how some people may be affected when high temperature and humidity are combined.

The higher a temperature-humidity index reading is, the more uncomfortable people are. Most people will feel comfortable with a temperature-humidity index below 75. Half or more will feel uncomfortable when the index is between 75 and 80. When the index reaches 80, most people will be uncomfortable. Serious health hazards, such as tiredness, dizziness, heatstroke, and heat exhaustion, can occur when the index reaches 85 or more (see **Sunstroke**).

The temperature-humidity index was developed in 1959 by the United States Weather Bureau (now the National Weather Service). It was originally called the *discomfort index.*

Tempering is a process of hardening glass and metals, especially steel. First, the steel is heated to a high temperature. Next, it is *quenched* (cooled rapidly) by plunging it into water, oil, or some other liquid. Then, it is heated again to a temperature lower than that used before quenching it, and is allowed to cool down slowly.

Tempering changes the internal structure of the steel. Different uses of steel require different properties, such as varying degrees of hardness, strength, and toughness. To obtain those properties, the structure of steel is changed by tempering it in different gases at various temperatures and for various lengths of time.

Thin films of iron oxide form on steel that is being heated in the tempering process. Those films have different colours, known as *temper colours,* which vary with the tempering temperature.

Glass is tempered in a somewhat similar way. It is heated until it becomes almost soft, then chilled by blasts of air or by plunging it into oil or other liquid. Glass that has been tempered may be up to five times as hard as ordinary glass. It may be used to hammer nails into wood. Some tempered glass can be struck by a hammer without breaking.

See also **Annealing.**

Templars, Knights. See **Knights Templars.**

Temple is a house of worship. The word *temple* usually refers to Buddhist, Confucian, Hindu, Taoist, and ancient Near Eastern and European places of worship. In Christianity, it is generally used only for certain Mormon buildings. In Judaism, Reform houses of worship are commonly called temples, but Conservative or Orthodox ones are usually called synagogues. The word rarely refers to an Islamic house of prayer, called a *mosque,* or to a Shinto shrine.

Most temples are built to honour God, a god, or many gods. Many of these buildings are considered the homes of gods. Worship at temples often involves traditional ceremonies and may include sacrifices. Many people visit temples as individuals or in small groups, rather than as members of large congregations.

A temple in Nara, Japan, called the Hall of the Great Buddha is the world's largest wooden building. A bronze statue of Buddha more than 15 metres high stands inside the temple.

Temples range from small, simple huts to huge, elaborately decorated buildings. Many contain a picture or statue of the honoured god. In a typical temple, the holiest image or object of worship is in a central room. To reach this area, worshippers may have to pass through a series of gates or doors that symbolize a spiritual journey. In many temples, only the clergy may enter the room. An altar stands inside or in front of many temples.

Certain temples stand on sacred sites. For example, some were built where people believed that miracles or divine revelations occurred. King Solomon of ancient Israel erected a temple in Jerusalem at the place where God was believed to have stopped a plague. This temple, which served as the centre of the Hebrew religion, is considered the most important one in the history of Western religion. Temples also have been built where people thought sacred forces flowed together in the most favourable way. Hindus and Taoists use an elaborate procedure involving the interpretation of divine signs to choose the most favourable location for a temple.

The design of numerous temples is symbolic. In eastern Asia, for example, a number of Buddhist temples are towerlike buildings called *pagodas,* which have many storeys. The storeys represent the levels of the earth and heaven, or the various spiritual goals that a Buddhist must achieve to gain salvation.

Related articles in ***World Book*** include:

Abu Simbel, Temples of
Architecture (pictures)
Greece, Ancient (pictures)
Indonesia (picture)
Japan (pictures)
Mormons (picture: The Mormon Temple)
Pagoda
Pantheon
Parthenon
Sculpture (picture: Kailasanatha Temple)
Sikhism (picture: Golden Temple)
World, History of the (pictures)

Temple, Henry John. See **Palmerston, Viscount.**

Temple, Shirley (1928-), was the most popular child film star of the 1930's. She made her film debut at the age of 3 and became a star in the 1934 film musical *Stand Up and Cheer.* Shirley Temple made about 25 films during the 1930's, including *Little Miss Marker* (1934), *The Little Colonel* (1935), *The Littlest Rebel* (1935), and *Dimples* (1936). She played teenage roles in many films during the 1940's, but these films were not as popular as her earlier ones.

Shirley Temple retired from films in 1949. She married Charles Black in 1950. In 1969, President Richard Nixon appointed her a U.S. representative to the United Nations General Assembly. In 1974, President Gerald Ford named her the U.S. ambassador to Ghana. In 1976 and 1977, she was chief of protocol in the Department of State, the first woman to hold that post. From 1989 to 1992, she served as ambassador to Czechoslovakia. Temple was born in Santa Monica, California, U.S.A.

Temple Bar was a gateway at the boundary of the City of London. The Temple Bar Memorial now stands on the site, at the junction of the Strand and Fleet Street in London. When visiting the city on state occasions, the sovereign still observes the custom of asking permission to enter the City. During the ceremony, the Lord Mayor of London offers the sovereign the sword of state. The sovereign returns it, making the Mayor responsible for protecting the sovereign in the City. A gateway was erected on the site in the early 1100's.

Temple of Artemis. See **Seven Wonders of the Ancient World.**

Temple of Solomon. See **Solomon; Jerusalem** (History).

Temple of Zeus. See **Olympia.**

Templer, Sir Gerald (1898-1979), was an English field-marshal who served as high commissioner in Malaya from 1952 to 1954. This was at the height of the Malayan Emergency during which communist forces tried to seize control of Malaya.

Gerald Walter Robert Templer was born in Colchester, England. He was the son of an army officer. Templer served in World War I (1914-1918) and World War II (1939-1945). When he was posted to Malaya in 1952, he faced a critical situation. A communist revolt had begun in 1948, and for the first four years the United Kingdom colonial administration achieved little success against the rebels. But Templer took vigorous and decisive measures to put down the communists, and ruthlessly punished civilian communities who helped them. He emphasized that the government's first aim was to win over the hearts and minds of the Malayan people.

When Templer left in 1954, the communists were no longer a serious threat to the Malayan government. In 1955, Templer became chief of the United Kingdom's Imperial General Staff.

Temples of Abu Simbel. See **Abu Simbel, Temples of.**

Ten Commandments are Biblical rules that state the basic religious and moral ideals of Judaism and Christianity. The commandments are also called the *Decalogue,* from two Greek words meaning *ten words.*

The Ten Commandments appear twice in the Old Testament—in Exodus 20:2-17 and Deuteronomy 5:6-21. The two versions differ slightly. The first group of commandments deals with duties toward God, and the second group concerns relations among people. Judaism and various Christian denominations number them differently. The list below reflects the numbering most commonly used in English-language references to the Ten Commandments:

> 1. I am the Lord thy God. Thou shalt have no other gods before me.
> 2. Thou shalt not make unto thee any graven image, or any likeness of any thing that is in heaven above, or that is in the earth beneath, or that is in the water under the earth. . . .
> 3. Thou shalt not take the name of the Lord thy God in vain. . . .
> 4. Remember the sabbath day, to keep it holy. . . .
> 5. Honour thy father and thy mother.
> 6. Thou shalt not kill.
> 7. Thou shalt not commit adultery.
> 8. Thou shalt not steal.
> 9. Thou shalt not bear false witness against thy neighbour.
> 10. Thou shalt not covet thy neighbour's house, thou shalt not covet thy neighbour's wife, nor his man- servant, nor his maidservant, nor his ox, nor his ass, nor any thing that is thy neighbour's.

In the Old Testament, the Ten Commandments appear as conditions of a *covenant* (agreement) between God and His chosen people, the Israelites. The Old Testament tells that the finger of God wrote the commandments on two stone tablets given to Moses on Mount Sinai. As Moses came down from the mountain, he saw the Israelites worshipping a golden calf. Enraged at the idol worship, Moses smashed the tablets. But at God's command, he carved the commandments into other stone tablets. The Israelites kept the tablets in a wooden ark (see **Ark of the Covenant**).

By the A.D. 200's, Christian teachers believed that God had stamped the commandments on the conscience of every human being, even before the laws were engraved on stone. Beginning in the A.D. 400's, everyone who became a Christian memorized the Ten Commandments. By the A.D. 800's, the laws had become a central part of church education. By the 1200's, the leading Christian scholars regarded them as principles of a universal natural law that governed human conduct. Protestant reformers of the 1500's included the Decalogue in their catechisms.

See also **Moses.**

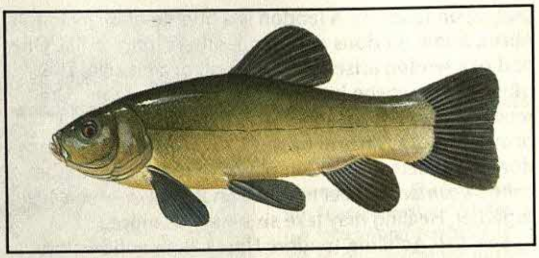
Tenant, in law, is a person who holds or possesses lands or buildings by any kind of title. In popular speech, a tenant is a person who has the right to occupy and use lands or buildings that belong to another person, known as the landlord. A *lease* (written agreement), signed by both owner and tenant, states the terms and period of time.

The relation of landlord and tenant had its origin in the feudal system of the Middle Ages. Some of the feudal obligations still survive in the present laws. The rights and duties of the *lessor* (landlord) and *lessee* (tenant) are generally defined in detail by the written lease.

A *tenant at will* occupies property for an indefinite period, which may be ended at any time by either landlord or tenant. Either may terminate a tenancy at will by expressing a wish that the tenancy should end.

A *tenant at sufferance* occupies property without the express consent of the owner or after the term of possession has expired. The tenant may be put off the property at any time by the landlord.

See also **Eviction; Lease.**



Tench

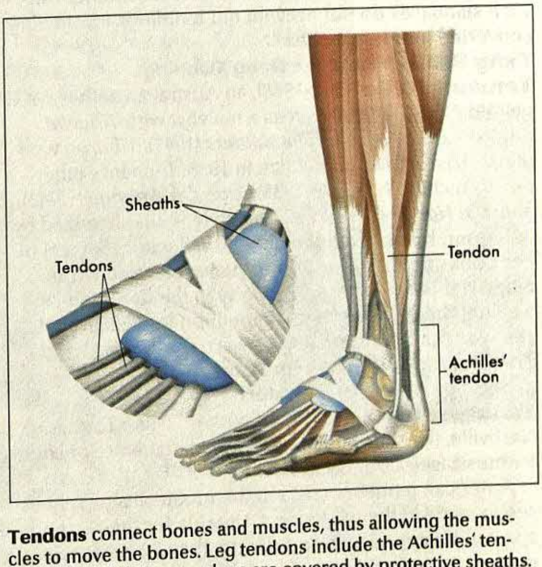
Tench is a fish with a heavy body and head, rounded fins, and small scales. It is usually a deep green or brown colour, sometimes with a bronze tinge. The skin secretes a lot of mucus, which makes the tench slimy. The tench lives in the still waters of lakes, rivers, and marshes. It eats dead animals and plants, insect larvae, crustaceans and molluscs. Tench lay small eggs on the leaves of water plants. The tench is native to Eurasia but has been introduced to North America, Australia, and New Zealand. It grows to over 60 centimetres long.

Scientific classification. The tench belongs to the carp family Cyprinidiae. It is *Tinca tinca.*

Tench, Watkin (1759?-1833), a British officer, wrote several accounts of life in the early period of the colony of New South Wales, Australia. Tench was born in Wales. He landed in Australia in January 1788, with the First Fleet, which brought the first group of convicts to Australia. He was in charge of the marine detachment onboard the transport *Charlotte.* He stayed in Australia for nearly four years and kept a diary of events in the colony. He made several journeys of exploration. On one of them, he sighted the Nepean River.

In 1789, Tench published *A Narrative of the Expedition to Botany Bay.* After his return to London, he wrote *A Complete Account of the Settlement at Port Jackson* (1793). Both these works give vivid and detailed descriptions of life in the early settlement.

Tendon, also called *sinew,* is a strong white cord that attaches muscles to bones. Muscles move bones by



Tendons connect bones and muscles, thus allowing the muscles to move the bones. Leg tendons include the Achilles' tendon at the heel. Foot tendons are covered by protective sheaths.

pulling on tendons. A tendon is a bundle of many tough fibres. Some tendons are round, others long or flat. One end of a tendon arises from the end of a muscle. The other end is woven into the substance of a bone. The tendon may slide up and down inside a sheath of fibrous tissue, as an arm moves in a coat sleeve. The tendon and sheath are held in place by connective tissue called *ligaments.* A cut tendon can be *sutured* (sewed) together. Healing may take six weeks or more.

See also **Achilles' tendon; Hand; Human body** (picture: Ligaments and tendons); **Muscle** (Skeletal muscles).

Tendring (pop. 125,100) is a local government district in northeast Essex, England. The inland area is devoted mainly to agriculture. The coastal towns of Brightlingsea, Clacton, Frinton-on-Sea, and Walton-on-the-Naze are popular seaside resorts. Tendring also serves as a residential area for people who work in Chelmsford, Colchester, and London. The district contains the port of Harwich, from which passengers and freight may travel to ports in Germany, Holland, and the Scandinavian countries. The port is equipped to handle containerized freight.

See also **Essex.**

Tenement is a term usually used to describe a crowded, decaying apartment building. But a tenement may refer to any dwelling that is rented to two or more families or tenants. A tenement can be an old residential building that has been divided to house low-income families at low standards. It can also be a new structure built for many low-income families—each in its own small apartment. An urban district that houses numerous tenements is often called a *slum.*

Tenements are strong income-producing properties. Each family may pay a low rent, but many people are crowded in small, poorly maintained areas. Thus, the rent per unit of area is often greater than that paid by middle-income people in larger and better apartments.

Historians believe tenements have existed since ancient times, when the Romans built them to house the poor and the slaves. Today, housing standards in many countries prevent construction of new tenements. But such standards do not prevent old buildings from being converted into tenements.

Teng Hsiao-p'ing. See **Deng Xiaoping.**

Tennant, Kylie (1912-1988), an Australian author, gained a major reputation as a novelist with *Tiburon,* published in 1935, and *The Battlers* (1941). *Tiburon* won the S. H. Prior Memorial Prize in 1935. Tennant's other novels include *Foveaux* (1939), *Ride On, Stranger* (1943), and *The Honey Flow* (1956). Her style is characterized by its vigour, humour, and intelligent reflection. Several of her books deal with social problems. She also wrote plays. Her play *Tether a Dragon* won the Commonwealth Jubilee Stage Play Competition in 1952. In 1960, she won the Children's Book Award for *All the Proud Tribesmen.* She was born in Sydney.

See also **Australian literature.**

Tennessee is a state in the Southern United States. Nashville, the state capital, is the leading centre of country music (see **Country music**).

American pioneers crossed the mountains of Tennessee to settle in the wilderness. Notable for their strong spirit of independence and daring, they formed their own governments in the region before any other independent government existed in North America. Later, during the American Civil War (1861-1865), many battles were fought in Tennessee.

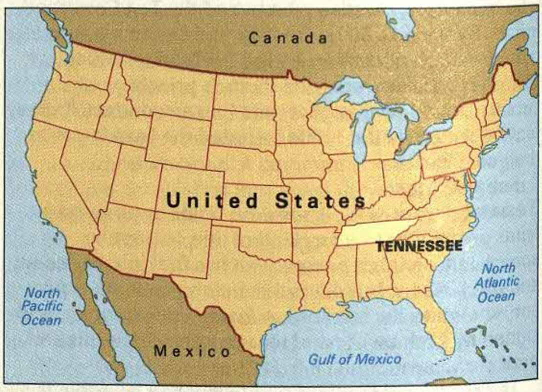
Land. Several mountain ranges lie on the eastern edge of Tennessee. A fertile ridge and valley region stretches westward from the mountains across to a plateau region with flat-topped mountains and V-shaped valleys.

A large, fertile basin lies in the centre of the state. It is surrounded by an elevated plain. The western part of the state, between the Tennessee River and the Mississippi River, is part of an important U.S. land region called the Gulf Coastal Plain. In Tennessee, this plain comprises a hilly strip of land in the east, low rolling hills and wide stream valleys in the centre, and a narrow plain in the west.

Economy. Manufacturing is Tennessee's most important economic activity. Tennessee is a major producer of chemicals. Other manufactured products include processed foods and beverages, machinery, and motor vehicles. Important service industries include education, health care, tourism, and trade. Memphis is a major national centre of wholesale trade.

History. Although Indians probably lived in the region at least 8,000 years ago, the earliest known groups were the Mound Builders. They settled the area about 1,000 years ago. Cherokee, Chickamauga, and Chickasaw Indians were living there when the first white explorers arrived.

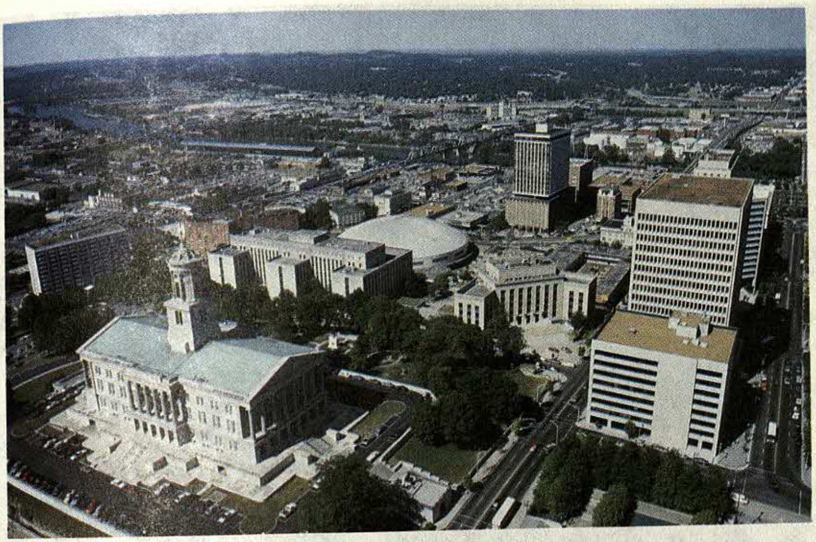
Spanish explorers entered the region during the 1500's. The British and French went there during the 1600's. Britain gained sole control of the region in 1763.



Tennessee is a state in the Southern United States. It links the North and the South of the country.

Facts in brief about Tennessee

Population: 4,896,641.
Area: 109,152 km².
Climate: *Average January temperature*—3° C. *Average July temperature*—26° C.
Largest cities: Memphis, Nashville, Knoxville, Chattanooga.
Chief products: *Agriculture*—beef cattle, milk, soybeans, pigs, tobacco, hay. *Manufacturing*—chemicals, food products, machinery, transportation equipment, printed materials, electrical equipment, fabricated metal products. *Mining*—coal, crushed stone, zinc.
Origin of name: *Tanasie,* a Cherokee village in the region.



Central Nashville includes the Tennessee State Capitol, *left foreground.* Nashville is the second largest city in Tennessee in population. It is one of the largest cities in area in the U.S.A., covering 1,373 square kilometres.

In 1796, Tennessee became the 16th U.S. state.

Two months after the American Civil War began in 1861, Tennessee became the last state to *secede* (withdraw) from the Union. On July 24, 1866, Tennessee became the first Confederate state to be readmitted.

In 1925, a Tennessee high school teacher, John T. Scopes, was convicted of violating a state law that prohibited teaching Darwin's theory of evolution. The trial aroused national controversy.

In 1933, the federal government established the Tennessee Valley Authority (TVA) to conserve and develop Tennessee River Valley resources.

An enormous music industry grew up in Nashville during the mid-1900's. On April 4, 1968, civil rights leader Martin Luther King, Jr., was killed in Memphis.

In 1985, the Tennessee River was connected to the Gulf of Mexico by the Tennessee-Tombigbee Waterway project.

See also **Scopes trial; Tennessee Valley Authority.**

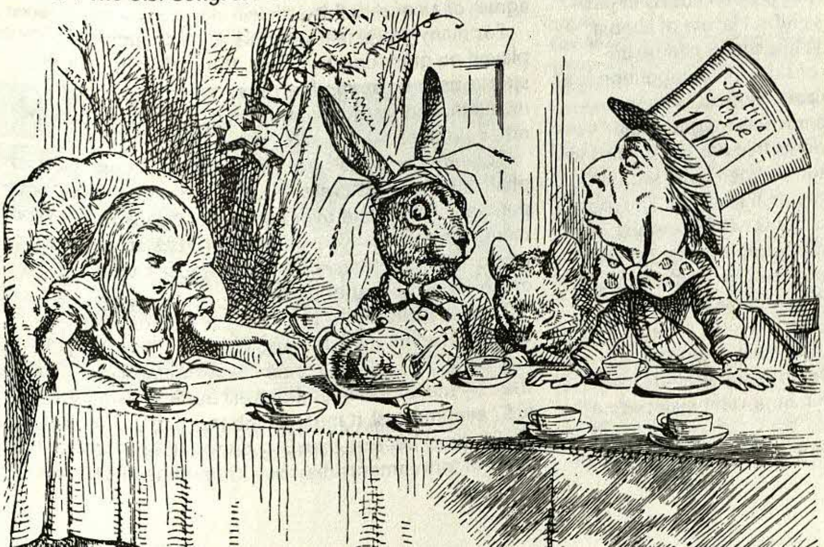
Tennessee Valley Authority (TVA) is a United States federal government corporation that works to develop the natural resources of the Tennessee Valley in the U.S.A. The U.S. Congress created TVA in 1933 and gave it the overall goal of conserving the resources of the valley region.

The creation of TVA became a highly controversial issue and remained so for many years. Private power companies strongly opposed government production of electric power. Political opponents of President Franklin Roosevelt's New Deal used the issue of the TVA's creation to embarrass him.

See also **New Deal; Roosevelt, Franklin Delana; Tennessee.**

Tenniel, Sir John (1820-1914), an English cartoonist and book illustrator, illustrated Lewis Carroll's *Alice's Adventures in Wonderland* (1865) and *Through the Looking-Glass* (1871). He also became famous for his political cartoons in *Punch,* a magazine for which he worked for about 50 years after 1850. His work was admired for its originality, dignity, and excellent technique. Tenniel and other artists of his time helped Great Britain keep leadership in the field of book illustration. He was born in London.

See also **Literature for children** (The rise of illustration; picture: *Through the Looking-Glass*); **Carroll, Lewis** (The *Alice* books).



Sir John Tenniel, *above,* became famous as the illustrator of Lewis Carroll's *Alice's Adventures in Wonderland.* His drawing of the mad tea party, *left,* expressed comic dignity.

Important tennis tournaments attract thousands of fans who come to watch the world's finest players compete against each other. The tournament held each summer in Wimbledon, England, *above,* ranks as the unofficial world championship for men and women players.

Tennis

Tennis is a game in which opposing players—one or two on each side—use rackets to hit a ball back and forth over a net. The game is played on a flat surface called a *court.* Each player tries to score points by hitting the ball so that the opposing player or players cannot return it over the net and inside the court.

Tennis may be played indoors or outdoors. If two people play, the game is called *singles.* If four people play, it is called *doubles.* In most singles and doubles matches, men play against men and women against women. In *mixed doubles,* a man and a woman play on each side.

Millions of people throughout the world play tennis for exercise and recreation. They play on courts in public parks and in private tennis clubs. Players of almost any age can enjoy the sport. While tennis can be enjoyed by players of any level of skill, top competition is a demanding test of both style and stamina.

Professional tennis players travel throughout the world to compete in tournaments that offer vast sums in prize money. Many countries enter men's and women's teams that compete for international trophies. The most famous team tournaments are the Davis Cup, which represents the world's men's team championship, the Federation Cup for women's teams, and the Wightman Cup between British and U.S. women's teams.

Tennis ranks as one of the world's most popular spectator sports as well as a favourite participant sport. Thousands of fans attend the many tournaments held each year. Millions more watch important matches on TV.

Tennis as it is played today developed in England during the late 1800's. The game quickly spread to other countries. By 1900, tennis had become a major international sport.

The court and equipment

The court is a rectangle divided into halves by a net stretched across the middle. The net measures 3 feet (91 centimetres) high at the centre and 3½ feet (107 centimetres) high at the side posts that support it. The court is 78 feet (23.7 metres) long. Almost all courts are marked off so that both singles and doubles games can be played on them. The singles court measures 27 feet (8.2 metres) wide. The doubles court is 4½ feet (1.37 metres) wider on each side. Various lines divide the singles and doubles court into sections. For the names of these lines and the sizes and names of the sections, see the diagram of a court in this article.

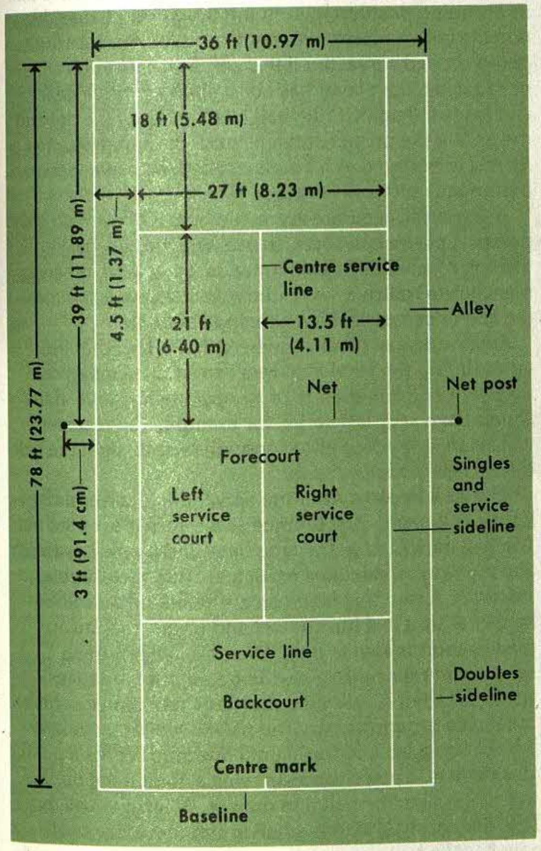
For many years, major tennis tournaments were played on grass courts. In fact, the early name for the sport was *lawn tennis.* But grass courts cost a lot to maintain, and so most of them have been replaced by other surfaces.

The most popular surfaces for outdoor courts are asphalt, clay, and concrete. Most indoor courts have a carpet-type surface laid over concrete or plywood. Several manufacturers have developed surfaces made of synthetic materials. Many of these surfaces can be laid on either indoor or outdoor courts.

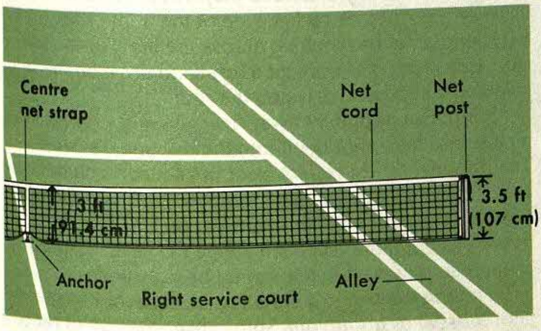
Tennis balls are hollow. They are made of rubber and covered with a felt fabric woven of Dacron, nylon, and wool. A tennis ball must have a diameter of more than 2½ inches (6.35 centimetres) but less than 2⅝ inches (6.67 centimetres). It must weigh more than 2 ounces (56.7 grams) but less than 2$\frac{1}{16}$ ounces (58.6 grams). Balls used in tournaments may be either white or yellow.

Manufacturers also make balls in other colours.

Tennis rackets. No rules govern the size and weight of a tennis racket, and so the models of various manufacturers differ slightly. But nearly all rackets measure 27 inches (68 centimetres) long. Most men choose a racket that weighs about 14 ounces (397 grams). Most women select one that weighs about 13 ounces (369 grams). Most young players use a racket that weighs about 9 ounces (255 grams). A typical racket frame is made of fibreglass and graphite. The most common striking surface is a net of tightly strung nylon or other synthetic material.



A tennis court is a rectangle divided into halves by a net. Various white lines further divide the court into sections.



The net is suspended across the court by a cable or cord. Two posts, one outside each doubles sideline, support the net. A narrow strap in the middle holds the net tight.

Tennis clothes should fit comfortably so that a player can move freely. During the late 1800's and early 1900's, men players wore long-sleeved shirts and trousers, and women wore ankle-length dresses. Such bulky clothing limited a player's movements. Today, men wear short-sleeved shirts and shorts. Women wear minidresses or blouses and short skirts.

Shoes are perhaps the most important item in a player's wardrobe. Tennis shoes are designed specially for the sport. They are made of cloth and have rubber soles and no heels. The shoes help keep players from slipping and do not damage the court.

How tennis is played

Before they begin to play tennis, the players must decide who serves first and which end of the court each player or team will defend. Some players make these decisions by means of a racket "toss." For example, they may use the manufacturer's markings on one side of a racket handle as "heads" and on the other side as "tails." One player stands the racket upright on the frame and spins it. The opposing player or team calls which side will land face up. Others call on the toss of a coin. If the call is correct, the player or team may either (1) choose to serve or receive first or (2) decide which end of the court to defend.

The court diagram in this article locates the various lines and playing areas discussed in this section.

Scoring. Tennis is scored in terms of points, games, and sets. A player or doubles team scores a *point* when the opposing side fails to return the ball properly or commits an error. To win a *game,* one side must score four points and lead by at least two points. The first

Terms used in tennis

Ace, or *service ace,* is a point scored by a server when the receiver is unable to touch a legal serve.

Deuce is a tie score after 6 points in a game or 10 games in a set.

Fault is called when a player serves into the net or outside the receiver's service court. A server commits a *foot fault* by stepping over the base line or changing position by walking or running before hitting the ball during a service. A server who makes two faults in a row commits a *double fault* and loses a point.

Game is the next highest unit of scoring after a point. To win a game, a player must score four points and lead by at least two points.

Ground stroke is any shot that a player uses after the ball bounces once on the court.

Let is a serve that hits the net and drops into the proper service court. A let does not count and is replayed.

Lob is a shot hit high into the air. It is intended to land behind an opponent, forcing the player to retreat from the net.

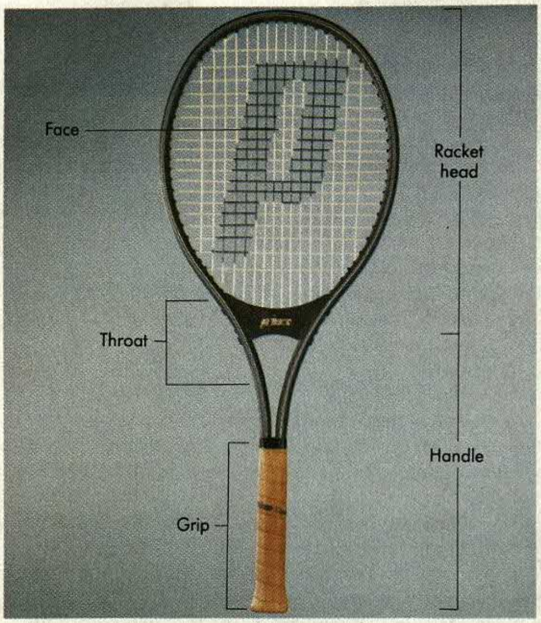
Love is the scoring term for zero.

Overhead smash is a hard swing at an opponent's shot from above the head.

Set is the highest unit of scoring in a match. To win a set, a player or team must win six games and lead by at least two games unless a tie breaker is played.

Tiebreaker is a play-off of a certain number of points to decide the winner of a set. Most tiebreakers are played after the game score reaches 6-6.

Volley is any shot made by hitting the ball before it bounces on the court.



A typical tennis racket has a frame made of 85 per cent fibreglass and 15 per cent graphite. The racket's face is a net of nylon or other synthetic material. Leather covers the grip.

point is called *15;* the second, *30;* the third, *40;* and the fourth, *game point.* A score of zero is called *love.* Historians are not certain how this scoring system began.

The server's score is always given first. For example, if the serving side leads three points to one, the score is *40-15.* If the receiving side wins the first two points, the score is *love-30.* If both sides win three points, the score is *40 - 40,* which is called *deuce.* To win a deuce game, one side must lead by two points. The first point scored after deuce is called the *advantage* or *ad* or *van.* If the side with the advantage loses the next point, the game returns to deuce.

To win a *set,* one side must win six games and lead by at least two games. If the game score is 5-5—a deuce set—play continues until one side has a two-game margin. In some tournaments, if the score reaches 6-6, a *tiebreaker* is played. It consists of a play-off of a certain number of points. The side that wins the tiebreaker wins the set by a score of 7-6.

In most competitions, the first side to win two sets wins the tennis *match.* In some tournaments, the first side to win three sets takes the match.

The serve, or *service,* puts the ball into play at the start of each game and after each point is scored. The server must toss the ball into the air and hit it before it strikes the ground. The ball must then travel into the service court diagonally opposite. The server begins each game by serving from the right-hand side of the court. The serve then alternates between the left- and right-sides following each point. The server must serve from behind the base line but may stand anywhere between the centre mark and the singles sideline.

In a singles match, a player serves until a game is completed. Then the receiver becomes the server. The players continue to alternate serves after each game. In a doubles match, the serve also changes sides after each game. But in addition, the members of each team alternate serves. If a team serves odd-numbered games, for example, one member would serve the first game, the other the third game, and so on. In both singles and doubles matches, the opposing players change ends of the court after the first, third, and all following odd-numbered games.

If a serve lands in the net or outside the receiver's service court, the server has committed a *fault.* A server commits a *foot fault* by stepping on or over the base line or changing position by running or walking before hitting the ball. A player who commits a fault or foot fault gets a second serve. But if this serve fails through a fault or foot fault, the player has committed a *double fault* and loses the point. If the ball hits the top of the net and drops into the proper service court, the serve is called a *let* and is replayed. A let is also called if a player serves before the receiver is ready.

A powerful, accurate serve can help a player win easy points. A player can serve an *ace,* which is a legal serve that the receiver is unable to touch. Even if the receiver manages to return a serve, the return may be so weak the server can easily hit a winning shot.

Receivers may stand anywhere on their end of the court during the service. A receiver often takes a position based on knowledge of an opponent's serve. If the server has a very fast serve, for example, the receiver will stand far back to allow enough time to sight the ball for the return shot.

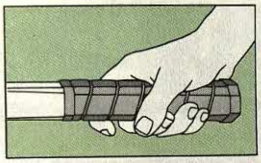
The ball in play. After the serve, the receiver must hit the ball on the first bounce and return it over the net. The ball must land in the area bounded by the base line and the singles sidelines or, in team play, the doubles sidelines. A shot that lands on a sideline or base line is in play. A shot that hits the net and drops into the opposing court is also in play. After the ball has been served and returned, it may be hit before it bounces, which is called a *volley,* or after the first bounce, which is called a *ground stroke.* The players continue to *rally* (hit the ball back and forth) until one side scores a point. During play, a player or team wins a point if the opposing side (1) hits the ball into the net, (2) hits the ball outside the court, (3) allows a ball to bounce twice or (4) touches the ball.

Players may use a variety of ground strokes and volleys. The basic shots are the *forehand drive* and the *backhand drive.* Right-handed players hit a forehand drive on the right, or racket, side of the body. They hit a backhand drive by reaching across the body to the left side. Left-handed players hit a forehand drive on the left side and a backhand drive on the right.

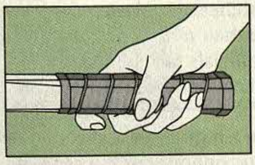
To force an opponent away from the net, a player may hit a *lob*—a high shot deep into the opponent's court. The opponent must retreat from the net to reach the ball. If the lob is not hit deep enough, however, the opponent may reply with an *overhead smash.* This shot is made by hitting the ball from above the head. A smash often is so powerful that it cannot be returned.

By hitting the ball in a certain way, a player can give a shot *topspin* or *underspin.* Spin causes the ball to react in such a way that it is difficult to return. A lob hit with topspin accelerates. A shot hit with underspin decelerates.

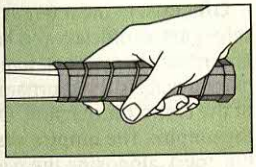
The grip is the way in which a player holds the racket. Most players use a grip called the *Continental grip* to serve and a form of the *Eastern grip* to hit forehand and backhand drives. In each grip, the player places the palm and fingers on the handle as shown on the right.



Continental serve

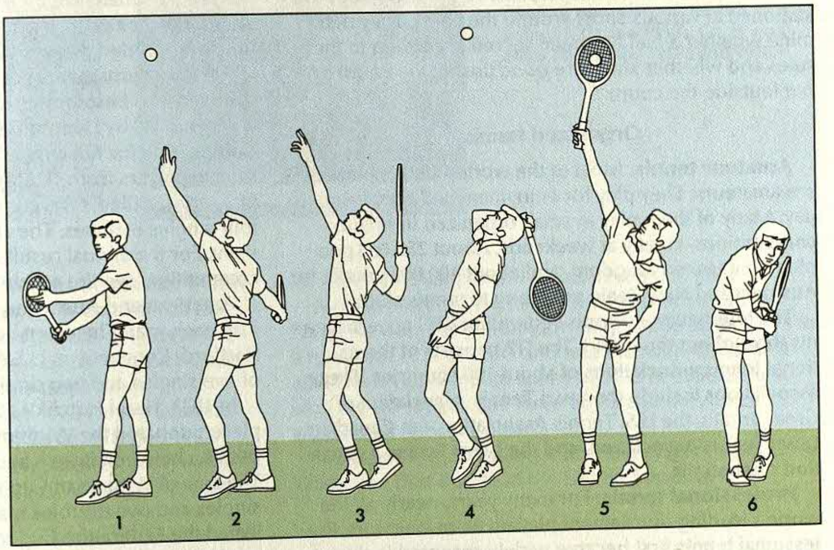


Eastern forehand

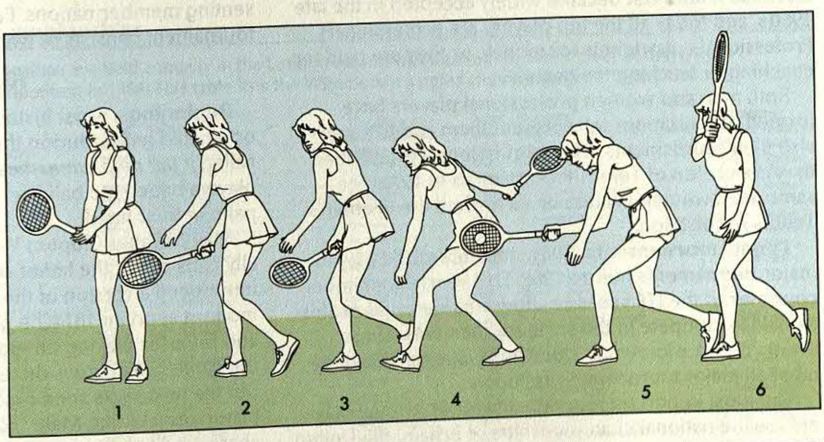


Eastern backhand

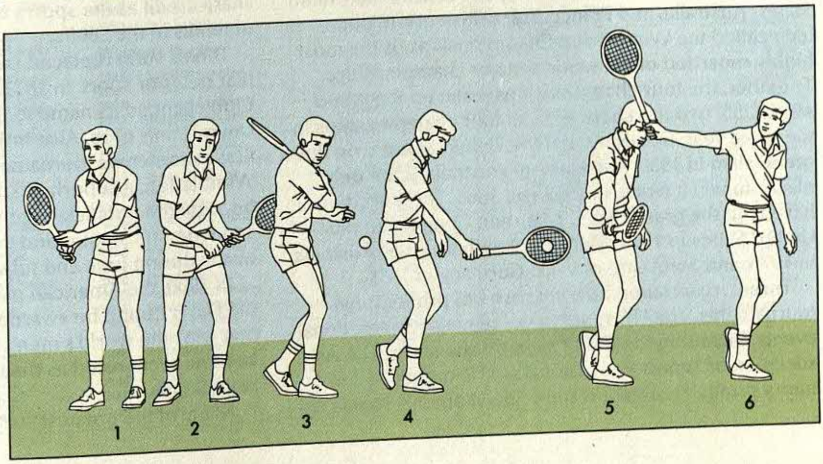
The serve. (1) The player, *right,* points his racket toward the net and places one foot comfortably behind the other. (2 and 3) He then tosses the ball into the air with his thumb and first two fingers and starts his backswing. (4) He next moves the racket back until it is behind him and pointing toward the ground. (5) The player then hits the ball with his arm fully extended and the ball slightly in front of him. (6) He ends the stroke with a strong follow-through.



The forehand drive. (1) The player, *right,* stands behind the spot where the ball will bounce. (2 and 3) She pivots her body and starts her backswing as the ball strikes the court. (4) As the ball bounces, she begins to bring the racket forward. (5) She hits the ball when it reaches a height between her knee and waist, keeping the racket parallel to the court. (6) Finally, she shifts her weight to her front foot while following through after hitting the shot.



The backhand drive. (1) The player, *right,* holds the grip with one hand and lightly grasps the throat of the racket with the other hand. (2) As he sights the ball, he turns his shoulder toward the net, pivots, and begins his backswing. (3) He ends the backswing with the racket behind him. (4 and 5) He then swings the racket forward, hip high and parallel to the court, and strikes the ball while it is still rising. (6) He follows through to complete the stroke.



Officials. In most tennis matches, the players themselves act as officials and keep their own score. But in an important tournament, many officials may be used. The chief official is the tournament referee, who has charge of the entire tournament. On the court, the top official is the umpire. The umpire sits on a high chair at the side of the court, alongside the net, and announces the score to the crowd. The umpire also supervises as many as 13 other officials, called linespersons. The linespersons are stationed at various spots around the court. They determine whether a ball has been served according to the rules and whether shots are *good* (inside the court) or *out* (outside the court).

Organized tennis

Amateur tennis. Most of the world's tennis players are amateurs. They play for enjoyment and receive no pay. Many of them play in small organized interclub competitions, chiefly at weekends. About 250,000 people in the United Kingdom, and about 400,000 people in Australia and New Zealand belong to tennis clubs.

The International Tennis Federation (ITF) governs tennis throughout the world. The ITF consists of the national tennis associations of about 100 countries. These associations include the Lawn Tennis Association of Great Britain, the U.S. Tennis Association, the Canadian Lawn Tennis Association, and the Lawn Tennis Association of Australia.

Professional tennis. For many years, nearly all the world's leading tournament players were amateurs. Professional tennis first became widely accepted in the late 1960's, and today all the top players are professionals. Professionals play tennis for money, or they are paid for coaching or teaching the game.

Both men and women professional players have formed organizations to represent them and to supervise their tournaments. Men professionals established the Association of Tennis Professionals in 1972. The same year, women professionals formed the Women's Tennis Association.

Tennis tournaments. Only amateurs could play in major tournaments before 1968. That year, the member countries of the ITF voted to allow amateurs and professionals to compete in the same tournaments. These events became known as *open* tournaments. Today, almost all major tournaments are open.

The most important tournaments for individual players are the national championships of Britain, the United States, Australia, and France. The British event, popularly called the Wimbledon Championships, is the most highly regarded of the world's major championships. Together, the four championships make up the *grand slam.* Only two men have won all four championships in the same year. Don Budge of the United States won the grand slam in 1938. Rod Laver of Australia is the only player to win it twice, in 1962 and 1969. Three women have won the grand slam—Maureen Connolly of the United States in 1953, Margaret Smith Court of Australia in 1970, and Steffi Graf of West Germany in 1988.

Three organizations are in charge of professional tournaments. The ITF supervises the major international events, including the grand slam tournaments. The Association of Tennis Professionals (ATP) organizes the men's professional tennis tour. The Women's Tennis Association (WTA) supervises the women's professional tour.

Most amateur and professional tournaments use a system called *seeding* to prevent the top players from meeting each other in an early round. The best player is seeded number one; the next best, number two; and so on. Players are seeded according to their records and reputations. In most tournaments, eight players are seeded. The matches are arranged so that seeded players do not face each other until the quarterfinal round, unless unseeded players defeat them.

Several tournaments are held for international team trophies. The best-known trophy is the Davis Cup, donated in 1900 by Dwight Davis, an American player. Competition for the cup takes place every year for teams of men players from 16 eligible nations. The teams meet in a series, called a *tie,* consisting of one doubles and four singles matches. The ITF supervises the tournament. For the annual results of the final round of cup competition, see the article **Davis Cup.**

American and Australian men compete for the World Cup each year. The event began in 1970 and is held in Hartford, Connecticut, U.S.A. The competition consists of five singles and two doubles.

In 1923, Hazel Hotchkiss Wightman, an American player, donated the Wightman Cup as a trophy for competition between British and American women's teams. The annual Wightman Cup tournament consists of five singles and two doubles matches. In 1963, the ITF established the Federation Cup for teams of women representing member nations. Each round in this elimination tournament consists of two singles and one doubles.

History

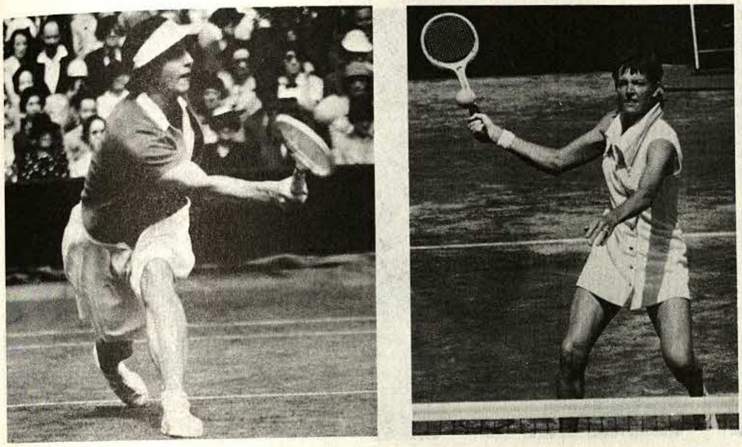
Beginnings. Most historians agree that the French originated tennis during the 1100's or 1200's. The French called it *jeu de paume,* meaning *game of the palm.* The players batted the ball back and forth over a net with the palm of their hand.

Major Walter Clopton Wingfield of England is generally considered the father of modern tennis. In 1873, he introduced a version of the game closely resembling the modern sport. In 1874, he patented tennis equipment and rules for playing on grass courts. Wingfield called the game *sphairistike,* the Greek word for *playing ball.* But the name was soon replaced by *lawn tennis.* Some historians feel that Major Harry Gem of England should share credit as the sport's founder. Gem played a form of tennis in the 1860's.

Tennis soon replaced croquet as England's most popular outdoor sport. In 1877, the All England Croquet Club changed its name to the All England Croquet and Lawn Tennis Club. Also in 1877, the club sponsored the first major tennis tournament at its headquarters in Wimbledon, a suburb of London. This tournament has become the unofficial world championship for men's and women's singles and doubles matches. It is held annually during June and July.

In 1900, the American player Dwight Davis donated the Davis Cup to be awarded annually to the country that wins the world's men's championship. The trophy became recognized as the top prize in international team tennis.

Many of the greatest stars in tennis history played



Great women players include, Helen Wills Moody of the United States, *far left,* and Margaret Smith Court of Australia, *left.* Moody starred in the 1920's and 1930's. Court won many titles in the 1960's and 1970's.

during the 1920's. But the period was dominated by Bill Tilden, an American who is generally considered the sport's finest player. Tilden won the U.S. singles title every year from 1920 to 1925 and again in 1929. He also won the Wimbledon singles title three times.

The top women players in the 1920's were Suzanne Lenglen of France and Helen Wills (later Helen Wills Moody) of the United States. Lenglen won six Wimbledon and six French championships. Moody won eight Wimbledon championships and seven U.S. titles.

A great player of the early 1930's was Britain's Fred Perry. He won the Wimbledon singles title three years in a row from 1934 to 1936, and was the main stay of Britain's Davis Cup winning teams of 1933 to 1936. He also won the US singles title three times and the Australian and French titles once each.

Perhaps the outstanding individual player of the 1930's was Don Budge of the United States. In 1938,

All-England (Wimbledon) Championships

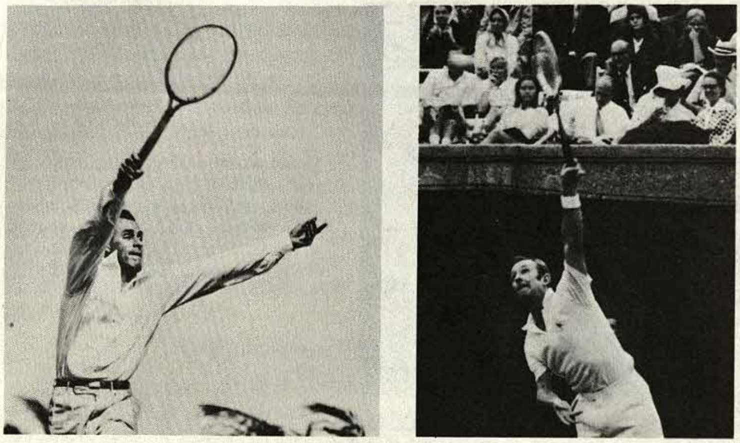
The All-England Championships are held annually in the London suburb of Wimbledon. Men's competition began in 1877, and women's competition in 1884. This table lists the Wimbledon singles champions since 1920.

Men's singles

Year	Winner	Country
1920	Bill Tilden	United States
1921	Bill Tilden	United States
1922	Gerald Patterson	Australia
1923	Bill Johnston	United States
1924	Jean Borotra	France
1925	René Lacoste	France
1926	Jean Borotra	France
1927	Henri Cochet	France
1928	René Lacoste	France
1929	Henri Cochet	France
1930	Bill Tilden	United States
1931	Sid Wood	United States
1932	Ellsworth Vines	United States
1933	Jack Crawford	Australia
1934	Fred Perry	Great Britain
1935	Fred Perry	Great Britain
1936	Fred Perry	Great Britain
1937	Don Budge	United States
1938	Don Budge	United States
1939	Bobby Riggs	United States
1940-45	No competition	
1946	Yvon Petra	France
1947	Jack Kramer	United States
1948	Bob Falkenburg	United States
1949	Ted Schroeder	United States
1950	Budge Patty	United States
1951	Dick Savitt	United States
1952	Frank Sedgman	Australia
1953	Vic Seixas	United States
1954	Jaroslav Drobny	Egypt
1955	Tony Trabert	United States
1956	Lew Hoad	Australia
1957	Lew Hoad	Australia
1958	Ashley Cooper	Australia
1959	Alex Olmedo	United States
1960	Neale Fraser	Australia
1961	Rod Laver	Australia
1962	Rod Laver	Australia
1963	Chuck McKinley	United States
1964	Roy Emerson	Australia
1965	Roy Emerson	Australia
1966	Manuel Santana	Spain
1967	John Newcombe	Australia
1968	Rod Laver	Australia
1969	Rod Laver	Australia
1970	John Newcombe	Australia
1971	John Newcombe	Australia
1972	Stan Smith	United States
1973	Jan Kodes	Czechoslovakia
1974	Jimmy Connors	United States
1975	Arthur Ashe	United States
1976	Björn Borg	Sweden
1977	Björn Borg	Sweden
1978	Björn Borg	Sweden
1979	Björn Borg	Sweden
1980	Björn Borg	Sweden
1981	John McEnroe	United States
1982	Jimmy Connors	United States
1983	John McEnroe	United States
1984	John McEnroe	United States
1985	Boris Becker	West Germany
1986	Boris Becker	West Germany
1987	Pat Cash	Australia
1988	Stefan Edberg	Sweden
1989	Boris Becker	West Germany
1990	Stefan Edberg	Sweden
1991	Michael Stich	Germany
1992	Andre Agassi	United States
1993	Pete Sampras	United States
1994	Pete Sampras	United States
1995	Pete Sampras	United States

Women's singles

Year	Winner	Country
1920	Suzanne Lenglen	France
1921	Suzanne Lenglen	France
1922	Suzanne Lenglen	France
1923	Suzanne Lenglen	France
1924	Kitty McKane	Great Britain
1925	Suzanne Lenglen	France
1926	Kitty McKane Godfree	Great Britain
1927	Helen Wills	United States
1928	Helen Wills	United States
1929	Helen Wills	United States
1930	Helen Wills Moody	United States
1931	Cilly Aussem	Germany
1932	Helen Wills Moody	United States
1933	Helen Wills Moody	United States
1934	Dorothy Round	Great Britain
1935	Helen Wills Moody	United States
1936	Helen Hull Jacobs	United States
1937	Dorothy Round	Great Britain
1938	Helen Wills Moody	United States
1939	Alice Marble	United States
1940-45	No competition	
1946	Pauline Betz	United States
1947	Margaret Osborne	United States
1948	Louise Brough	United States
1949	Louise Brough	United States
1950	Louise Brough	United States
1951	Doris Hart	United States
1952	Maureen Connolly	United States
1953	Maureen Connolly	United States
1954	Maureen Connolly	United States
1955	Louise Brough	United States
1956	Shirley Fry	United States
1957	Althea Gibson	United States
1958	Althea Gibson	United States
1959	Maria Bueno	Brazil
1960	Maria Bueno	Brazil
1961	Angela Mortimer	Great Britain
1962	Karen Hantze Susman	United States
1963	Margaret Smith	Australia
1964	Maria Bueno	Brazil
1965	Margaret Smith	Australia
1966	Billie Jean King	United States
1967	Billie Jean King	United States
1968	Billie Jean King	United States
1969	Ann Haydon Jones	Great Britain
1970	Margaret Smith Court	Australia
1971	Evonne Goolagong	Australia
1972	Billie Jean King	United States
1973	Billie Jean King	United States
1974	Chris Evert	United States
1975	Billie Jean King	United States
1976	Chris Evert	United States
1977	Virginia Wade	Great Britain
1978	Martina Navratilova	United States
1979	Martina Navratilova	United States
1980	Evonne Goolagong	Australia
1981	Chris Evert Lloyd	United States
1982	Martina Navratilova	United States
1983	Martina Navratilova	United States
1984	Martina Navratilova	United States
1985	Martina Navratilova	United States
1986	Martina Navratilova	United States
1987	Martina Navratilova	United States
1988	Steffi Graf	West Germany
1989	Steffi Graf	West Germany
1990	Martina Navratilova	United States
1991	Steffi Graf	Germany
1992	Steffi Graf	Germany
1993	Steffi Graf	Germany
1994	Conchita Martinez	Spain
1995	Steffi Graf	Germany



Great men players include Bill Tilden of the United States, *far left,* and Rod Laver of Australia, *left.* Tilden dominated international competition throughout the 1920's. Laver was the world's leading player during the 1960's.

Budge became the first player to win the grand slam.

The mid-1900's. Until the 1950's, France, Great Britain, and the United States produced almost all the world's major players. Then Australia became the leading country in men's competition. From 1950 to 1967, Australian teams won the Davis Cup 15 times. Such players as Roy Emerson, Lew Hoad, Rod Laver, John Newcombe, Ken Rosewall, Frank Sedgman, and Fred Stolle helped Australia maintain its top position in international men's tennis.

During the 1940's and 1950's, several American players achieved worldwide success. The most notable included Pancho Gonzales, Jack Kramer, Art Larsen, Frank Parker, Ted Schroeder, Vic Seixas, and Tony Trabert.

United States Open

The United States Open is held annually in Flushing Meadow in New York City. This table lists U.S. Open winners since competition was opened to professionals in 1968. The champions listed before 1968 were winners of amateur competitions called the United States National Championships. Men's competition began in 1881, and women's in 1887. This table lists U.S. singles champions since 1920.

Men's singles

Year	Winner	Country
1920	Bill Tilden	United States
1921	Bill Tilden	United States
1922	Bill Tilden	United States
1923	Bill Tilden	United States
1924	Bill Tilden	United States
1925	Bill Tilden	United States
1926	René Lacoste	France
1927	René Lacoste	France
1928	Henri Cochet	France
1929	Bill Tilden	United States
1930	John Doeg	United States
1931	Ellsworth Vines	United States
1932	Ellsworth Vines	United States
1933	Fred Perry	Great Britain
1934	Fred Perry	Great Britain
1935	Wilmer Allison	United States
1936	Fred Perry	Great Britain
1937	Don Budge	United States
1938	Don Budge	United States
1939	Bobby Riggs	United States
1940	Don McNeill	United States
1941	Bobby Riggs	United States
1942	Ted Schroeder	United States
1943	Joe Hunt	United States
1944	Frank Parker	United States
1945	Frank Parker	United States
1946	Jack Kramer	United States
1947	Jack Kramer	United States
1948	Pancho Gonzales	United States
1949	Pancho Gonzales	United States
1950	Art Larsen	United States
1951	Frank Sedgman	Australia
1952	Frank Sedgman	Australia
1953	Tony Trabert	United States
1954	Vic Seixas	United States
1955	Tony Trabert	United States
1956	Ken Rosewall	Australia
1957	Mal Anderson	Australia
1958	Ashley Cooper	Australia
1959	Neale Fraser	Australia
1960	Neale Fraser	Australia
1961	Roy Emerson	Australia
1962	Rod Laver	Australia
1963	Rafael Osuna	Mexico
1964	Roy Emerson	Australia
1965	Manuel Santana	Spain
1966	Fred Stolle	Australia
1967	John Newcombe	Australia
1968	Arthur Ashe	United States
1969	Rod Laver	Australia
1970	Ken Rosewall	Australia
1971	Stan Smith	United States
1972	Ilie Nastase	Romania
1973	John Newcombe	Australia
1974	Jimmy Connors	United States
1975	Manuel Orantes	Spain
1976	Jimmy Connors	United States
1977	Guillermo Vilas	Argentina
1978	Jimmy Connors	United States
1979	John McEnroe	United States
1980	John McEnroe	United States
1981	John McEnroe	United States
1982	Jimmy Connors	United States
1983	Jimmy Connors	United States
1984	John McEnroe	United States
1985	Ivan Lendl	Czechoslovakia
1986	Ivan Lendl	Czechoslovakia
1987	Ivan Lendl	Czechoslovakia
1988	Mats Wilander	Sweden
1989	Boris Becker	West Germany
1990	Pete Sampras	United States
1991	Stefan Edberg	Sweden
1992	Stefan Edberg	Sweden
1993	Pete Sampras	United States
1994	Andre Agassi	United States

Women's singles

Year	Winner	Country
1920	Molla Bjurstedt Mallory	United States
1921	Molla Bjurstedt Mallory	United States
1922	Molla Bjurstedt Mallory	United States
1923	Helen Wills	United States
1924	Helen Wills	United States
1925	Helen Wills	United States
1926	Molla Bjurstedt Mallory	United States
1927	Helen Wills	United States
1928	Helen Wills	United States
1929	Helen Wills	United States
1930	Betty Nuthall	Great Britain
1931	Helen Wills Moody	United States
1932	Helen Hull Jacobs	United States
1933	Helen Hull Jacobs	United States
1934	Helen Hull Jacobs	United States
1935	Helen Hull Jacobs	United States
1936	Alice Marble	United States
1937	Anita Lizana	Chile
1938	Alice Marble	United States
1939	Alice Marble	United States
1940	Alice Marble	United States
1941	Sarah Palfrey Cooke	United States
1942	Pauline Betz	United States
1943	Pauline Betz	United States
1944	Pauline Betz	United States
1945	Sarah Palfrey Cooke	United States
1946	Pauline Betz	United States
1947	Louise Brough	United States
1948	Margaret Osborne duPont	United States
1949	Margaret Osborne duPont	United States
1950	Margaret Osborne duPont	United States
1951	Maureen Connolly	United States
1952	Maureen Connolly	United States
1953	Maureen Connolly	United States
1954	Doris Hart	United States
1955	Doris Hart	United States
1956	Shirley Fry	United States
1957	Althea Gibson	United States
1958	Althea Gibson	United States
1959	Maria Bueno	Brazil
1960	Darlene Hard	United States
1961	Darlene Hard	United States
1962	Margaret Smith	Australia
1963	Maria Bueno	Brazil
1964	Maria Bueno	Brazil
1965	Margaret Smith	Australia
1966	Maria Bueno	Brazil
1967	Billie Jean King	United States
1968	Virginia Wade	Great Britain
1969	Margaret Smith Court	Australia
1970	Margaret Smith Court	Australia
1971	Billie Jean King	United States
1972	Billie Jean King	United States
1973	Margaret Smith Court	Australia
1974	Billie Jean King	United States
1975	Chris Evert	United States
1976	Chris Evert	United States
1977	Chris Evert	United States
1978	Chris Evert	United States
1979	Tracy Austin	United States
1980	Chris Evert Lloyd	United States
1981	Tracy Austin	United States
1982	Chris Evert Lloyd	United States
1983	Martina Navratilova	United States
1984	Martina Navratilova	United States
1985	Hana Mandlikova	Czechoslovakia
1986	Martina Navratilova	United States
1987	Martina Navratilova	United States
1988	Steffi Graf	West Germany
1989	Steffi Graf	West Germany
1990	Gabriela Sabatini	Argentina
1991	Monica Seles	Yugoslavia
1992	Monica Seles	Yugoslavia
1993	Steffi Graf	Germany
1994	Arantxa Sanchez Vicario	Spain

Modern women tennis stars include, *from left to right,* Chris Evert and Martina Navratilova of the United States and Steffi Graf of Germany. Evert and Navratilova dominated the sport from the mid-1970's to the late 1980's, when Graf became the leading player.

The United States provided most of the top women stars from the mid-1940's to the mid-1960's. They included Louise Brough, Maureen Connolly, Margaret Osborne duPont, and Doris Hart. Connolly was probably the greatest woman player of this period. In 1953, she became the first woman to win the grand slam.

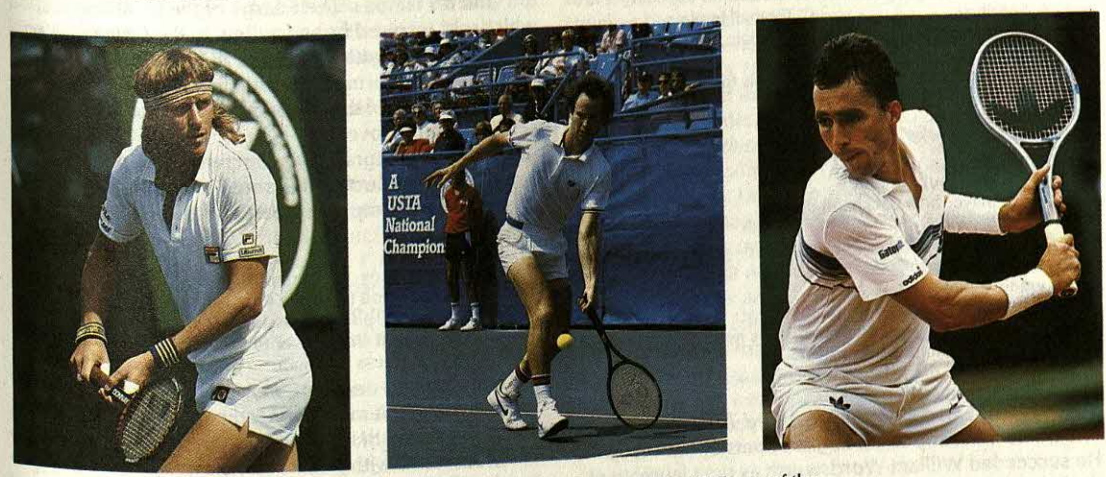
Althea Gibson of the United States became the first important black tennis player. She won the U.S. and Wimbledon titles in 1957 and 1958. In the late 1960's, Arthur Ashe of the United States became the first black male tennis star. In 1968, he won the U.S. singles championship, and won the Wimbledon singles title in 1975.

Laver ranked as the top male star of the 1960's. The Australian became the only player to win the grand slam twice, in 1962 as an amateur and in 1969 as a professional. Other leading male players of the 1960's included Manuel Santana of Spain and Stan Smith of the United States. In the 1960's, Margaret Smith (later Margaret Smith Court) became the first Australian woman to win both the Wimbledon and U.S. singles titles. She won the grand slam in 1970. Maria Bueno of Brazil and Billie Jean King of the United States also ranked as important players of the period.

Tennis today. International tennis has largely been a professional sport since 1968. Professionals compete for vast sums in prize money annually. Television played an important role in increasing the popularity of tennis during the 1970's and 1980's. Major tournaments are televised to many countries.

Several highly publicized matches were arranged largely for television audiences. In 1973, Bobby Riggs, a top-ranked American player of the late 1930's and 1940's, defeated Margaret Smith Court in a televised "battle of the sexes." Later that year, Riggs played Billie Jean King in the Houston Astrodome in Houston, Texas, U.S.A., before 30,472 spectators, the largest crowd ever to watch a tennis match. Millions more people watched on TV as King defeated Riggs.

The Davis Cup became a centre of political dispute in the 1970's. In 1974, South Africa won the cup by forfeit



Modern men tennis stars include, *from left to right,* Björn Borg of Sweden, John McEnroe of the United States, and Czech-born Ivan Lendl. Borg was the top player in the world in the 1970's. McEnroe and Lendl ranked among the top international players of the 1980's.

from India. The Indian government refused to allow its team to play because of South Africa's *apartheid* (racial separation) policies. The Davis Cup had already lost some of its importance because many professionals refused to play for their countries. These players claimed that the many weeks of cup play-offs would force them to miss too many tournaments. In 1981, Davis Cup competition was changed to attract more top players. It was compressed into a shorter period of time and the prize money was increased.

The most successful men players of the 1970's and early 1980's included Björn Borg of Sweden; Jimmy Connors, and John McEnroe of the United States. Leading women players included Evonne Goolagong of Australia; Virginia Wade of the United Kingdom; Chris Evert, and Martina Navratilova of the United States. By the mid-1980's, another group of players began to dominate the sport. The leading men were the Australian Pat Cash, Czech-born Ivan Lendl, Mats Wilander and Stefan Edberg of Sweden, and Boris Becker of Germany. The top women players included Gabriela Sabatini of Argentina; Steffi Graf of Germany; and Monica Seles of Yugoslavia. In the early 1990's, a new group of young players had begun to appear. These include Andre Agassi, Pete Sampras, and Jim Courier of the United States. The most successful young women players include Arantxa Sanchez Vicario of Spain, and Jennifer Capriati of the United States.

In 1990, Navratilova won the women's singles championship at Wimbledon for the ninth time. No woman had ever won a singles title at Wimbledon more than eight times in the history of modern tennis.

Related articles in ***World Book*** include:

Ashe, Arthur
Badminton
Becker, Boris
Borg, Björn
Connors, Jimmy
Davis Cup
Evert, Chris
Gibson, Althea
Gonzales, Pancho
King, Billie Jean
Laver, Rod
Lendl, Ivan
McEnroe, John
Navratilova, Martina
Table tennis
Wills, Helen N.

Outline

- **I. The court and equipment**
  - A. The court
  - B. Tennis balls
  - C. Tennis rackets
  - D. Tennis clothes
- **II. How tennis is played**
  - A. Scoring
  - B. The serve
  - C. The ball in play
  - D. Officials
- **III. Organized tennis**
  - A. Amateur tennis
  - B. Professional tennis
  - C. Tennis tournaments
- **IV. History**

Questions

What is an open tournament?
How does a player hit a backhand drive?
What is a *tiebreaker*?
Why have most grass courts been replaced by other surfaces?
What is a *fault*? A *double fault*?
When would a player hit a smash?
What is the Davis Cup? The Wightman Cup?
Where are the All-England Championships held? Where are the United States Championships held?
Who is considered the father of modern tennis?

Tennyson, Lord (1809-1892), *Alfred Tennyson,* was one of the most important English poets of the 1800's. He succeeded William Wordsworth as poet laureate of the United Kingdom in 1850. Tennyson earned his position in literature because of the remarkable range of his natural talents and his dedication throughout his long career to perfecting his art. Tennyson stands today both as a great national poet and as one of the supreme craftsmen in the English language.

Oil portrait by M. Armault, National Portrait Gallery, London

Lord Tennyson

His life. Alfred Tennyson was born on Aug. 6, 1809, in Somersby, Lincolnshire, England. His father was *rector* (clergyman in charge) of the parish there.

Tennyson entered Cambridge University in 1828, but he never received a degree. At Cambridge, he joined "The Apostles," a society of undergraduates that included several men who later became intellectual leaders of the age. Tennyson's most intimate friend in this circle was Arthur Henry Hallam. Hallam's sudden death in 1833 was a crucial event in the poet's generally uneventful life. Tennyson began to write his great *elegy* (poem mourning a death) *In Memoriam* in memory of Hallam, which was published in 1850.

Tennyson was the most popular British poet of the Victorian era, but he avoided public life. He married in 1850 and lived quietly in his country homes at Farringford on the Isle of Wight and Aldworth in Surrey. Tennyson's long list of works showed his consistent inspiration and creative vitality, beginning with *Poems, Chiefly Lyrical* (1830) and extending to *The Death of Oenone and Other Poems,* published after his death more than 60 years later. He was awarded the title of Baron Tennyson in 1883 by Queen Victoria. His full title was Baron of Aldworth and Farringford. Tennyson died on Oct. 6, 1892, and was buried in the Poets' Corner of Westminster Abbey.

His poems. Tennyson's influential place in the intellectual life of his age comes largely from his concern about the vital issues confronting Victorian England. He reveals his sense of political responsibility in such patriotic verses as "Ode on the Death of the Duke of Wellington" and his famous "The Charge of the Light Brigade," which was inspired by an incident in the Crimean War (see **Balaklava, Battle of**). *Maud: A Monodrama* was a narrative in the form of separate lyrics, describing the withering effect of the materialistic spirit of his day on a sensitive young lover.

Tennyson's accurate and concrete descriptions of the natural world reflect his informed interest in science. The stars, for example, suggest to the unhappy speaker in *Maud:*

> A sad astrology, the boundless plan
> That makes you tyrants in your iron skies,
> Innumerable, pitiless, passionless eyes,
> Cold fires, yet with power to burn and brand
> His nothingness into man.

Tennyson's masterpiece, *In Memoriam,* consists of 133 individual poems composed between his friend Arthur Hallam's death in 1833 and their publication in 1850. The work ranks with John Milton's *Lycidas* and Percy Bysshe Shelley's *Adonais* as one of the greatest examples of the elegy in English poetry. *In Memoriam* is personal and specific in its focus on Tennyson's struggles as an artist and thinker. The poem frequently offers general consolation to a troubled age:

> I stretch lame hands of faith and grope,
> And gather dust and chaff, and call
> To what I feel is Lord of all,
> And faintly trust the larger hope.

Perhaps no English poet had a more acute ear for fine shades of poetic expression or a greater range of verse style than Tennyson. His exquisite lyrics perfectly express emotions and experiences shared by all people. Among the most moving of these are many of the sections from *In Memoriam,* as well as "Break, Break, Break" and "Tears, Idle Tears." Following the author's wishes, "Crossing the Bar," the noble address to death, always ends collections of his poems.

Tennyson's most characteristic form of poetry was the idyl, a poem about country life developed by the ancient Greeks. These poems often take the form of dramatic *reveries* (daydreams) spoken by mythical figures. They tell a story, but depend primarily on the creation of mood through the power of richly described settings, as in "The Lotos-Eaters." Many of these stories indirectly urge Victorians to act heroically. The speakers commonly fall into two groups: the lovelorn maidens of "Mariana," "The Lady of Shalott," and "Oenone"; and the aged heroes and prophets of "Ulysses," "Tithonus," "Tiresias," and "Merlin and the Gleam."

Tennyson's lifelong fascination with King Arthur and his knights led to his most ambitious work, *Idylls of the King.* It is a series of 12 narrative poems that he published with constant revisions between 1842 and 1885. The work has an *allegorical* (symbolic) side, suggested by the many implied comparisons between Arthur and Queen Victoria's husband, Prince Albert, who had died in 1861. The work also ends with an allegorical *epilogue* (closing) to the queen with its invitation to:

> accept this old imperfect tale
> New-old, and shadowing Sense at war with Soul,
> Ideal manhood closed in real man . . .

Nevertheless, the poem is most likely to move a modern audience as the story of King Arthur's vision of the perfect state. This vision was betrayed by the inability of King Arthur's followers to live up to his heroic ideals.

See also **Galahad, Sir; January** (Quotations); **Poetry** (Introduction).

Tenochtitlan. See **Aztec** (Introduction; History); **Cuauhtémoc.**

Tenor is the second highest male singing voice. Only a man who sings *countertenor* (contralto) can sing higher (see **Contralto**). Most tenors have a vocal range that goes from about an octave below middle C to the B flat above middle C. Middle C is the note C that lies nearest to the centre of a piano keyboard. Most operatic tenors specializing in dramatic roles can sing notes that are even higher than the top of the normal range.

Tenpins. See **Bowling.**

Tenrec is the name of about 30 species of small mammals that live primarily in Madagascar. There are two main types, *shrew tenrecs* and *hedgehog tenrecs.* They vary widely in appearance and habitat. Shrew tenrecs have a long tail and soft fur. Hedgehog tenrecs have a short tail or no tail at all, and stiff, needlelike spines on the back. Some tenrecs live in trees, some live underground, and others are aquatic.

Tenrecs range in size from about 4 to 38 centimetres in length. They have small eyes, small ears, and a long nose with long whiskers. Tenrecs eat small animals, especially insects and earthworms. Some species also eat fruit and other plant material. Most tenrecs move about at night and sleep during the day. Tenrecs may hibernate during periods of dry or cool weather for up to six months.

Scientific classification. Tenrecs belong to the tenrec family, Tenrecidae.

Tense is a feature of verbs that indicates the time of an action. There are three divisions of time—present, past, and future. Within these divisions, English has six tenses—present, past, future, present perfect, past perfect, and future perfect.

Only two forms of English verbs can express time by themselves. These are the simple present, as in *She sees,* and the simple past, as in *She saw.* All other forms are phrases that include *helping verbs,* also called *auxiliaries.* Such forms combine helping verbs with the simple present (*see*), the present participle (*seeing*), or the past participle (*seen*). The following list shows all six tenses:

Present	She sees.
Past	She saw.
Future	She will see.
Present perfect	She has seen.
Past perfect	She had seen.
Future perfect	She will have seen.

These tenses are written in the active voice and indicative mood. For a complete list of the tenses for all forms of a verb, see **Conjugation.**

The *progressive* forms of a verb indicate that an action is in progress at a particular time—for example, *She is seeing the picture for the first time.* The *emphatic* forms provide emphasis, as in *She does see.* However, this form is more commonly used to ask questions, such as *Does she see?* It is also used to make negative statements, such as *She does not see.*

The perfect tenses express time relationships other than simple present, past, and future. The present perfect expresses an action that belongs to the past but touches the present: *Until now, we have seen Paris three times.* The past perfect expresses an action completed at some past time: *In 1945, we had seen Paris only once.* The future perfect expresses an action to be completed at some future time: *By next year, we will have seen Paris for the fourth time.*

Perfect tenses sometimes express special kinds of action. For example, *We keep seeing ugly billboards* shows repeated action. *We used to see better times than we do now* expresses past continuing action. *We go on seeing what we want to see* shows present continuing action. *We are about to see an amazing feat* expresses action to come.

Future time is expressed by the auxiliaries *will* and *shall.* Future time is also indicated by the present tense plus an adverbial expression: *He sails tomorrow.* In addition, future time can be expressed by other forms:

He is sailing tomorrow.
He is to sail tomorrow.
He is going to sail tomorrow.

Literary uses of tense. Many writers, especially historians and storytellers, use the present tense to tell about the past. This technique, called the *historical present,* provides a quality of vividness and immediacy. The present tense also is often used to describe any published work—for example, *The story of* Alice in Wonderland *includes many fantastic characters and incidents.*

Tenses follow natural sequences, depending on the wishes of the author. A writer generally chooses a tense and maintains it unless a change seems desirable. For example, an author might want to discuss the working conditions in a particular industry. The writer could begin by describing conditions in past years, then follow with an account of present conditions, and end with ideas about developments in the future. The tenses would reflect these changes.

See also **Verb.**

Tenskwatawa. See **Shawnee Prophet.**

Tent is a portable shelter that many campers use for protection against the weather and insects. Most tents consist of a wooden, fibreglass, or metal frame with a covering and floor made of nylon, canvas, or cotton.

Tents are made in a variety of sizes and styles. They range from small models for one person to large cabin tents for as many as six adults. Extremely large tents are used for such activities as carnivals, circuses, and church meetings. This article discusses camping tents.

Kinds of tents. There are many styles and sizes of camping tents. However, most of them are variations of one of four basic types: (1) A-frame tents, (2) dome and hoop tents, (3) umbrella tents, and (4) wall tents.

A-frame tents rise to a point at the top and resemble the letter *A.* One or two people can sleep in these small, lightweight tents, which are ideal for backpack trips. These tents are easy to pitch and relatively inexpensive.

Dome and hoop tents use arches in their design. They are lightweight but provide maximum space. Most mountaineering tents made for year-round use have a dome or hoop design. Because of their shape these tents are stable and shed rain, snow, and wind well. Most of them are free standing. Two to four people can sleep in them.

Umbrella tents are larger and heavier than A-frame tents. An umbrella tent has slightly slanted walls and a pyramid-shaped top. Some models have a centre pole that decreases the space inside the tent, but newer ones lack this pole. Umbrella tents have sleeping space for four to six people. They are sturdy shelters that can withstand high winds.

Wall tents resemble small houses. They have vertical walls and an A-frame roof. They provide more sleeping and standing room than A-frame or umbrella tents but are harder to pitch. One kind of wall tent, the *cabin tent,* offers the highest degree of camping comfort. Its spacious interior and high walls allow more room for standing, walking, and sleeping than any other kind of tent. Wall tents and most umbrella tents are too large and heavy to carry in a backpack. They are used mainly by campers who drive to campsites.

Most tents of all kinds are made of canvas or nylon. Canvas tents weigh much more but are less likely to leak. Some nylon tents are specially treated to prevent leakage. However, this treatment also seals moisture inside the tent and may cause the interior to become damp. Some nylon tents have a canvas roof that lets moisture escape. Most have a roof with an untreated nylon layer through which moisture can pass, plus a treated nylon covering, called a *fly sheet,* which keeps rain out.

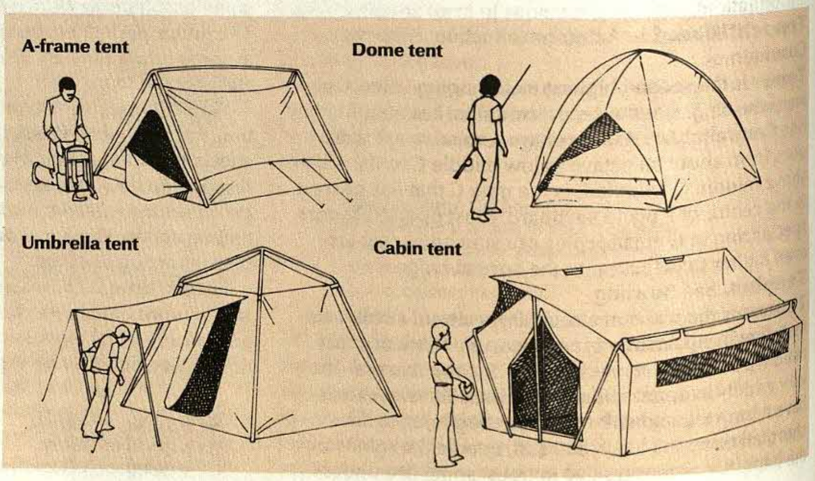
All tents provide some type of ventilation and protection against rain and insects. Cabin tents have large windows and a door, and smaller tents have vents and a door flap. Usually, these openings are covered with netting that keeps insects out. Many tents have flaps to close over the windows during a storm. Some have a storm flap that can be put over the entire tent.

Pitching a tent. Before setting up camp, campers should find a suitable spot to pitch their tent. The ideal campsite lies on high, level ground near trees and has fresh water nearby. Camping on high ground helps prevent the tent from being flooded during a storm. If a tent is pitched on low ground, a shallow trench should be dug around it to keep water out. Campers should not pitch a tent close to trees with dead branches that could break off and strike the tent.

In most cases, the first step in pitching a tent is to spread out the floor and secure it to the ground with stakes. The stakes are driven into the ground through

Some kinds of tents

Tents are manufactured in many sizes and styles. They range from small shelters for one or two people to much larger tents that can sleep up to six adults. Some popular kinds of tents are shown on the right.



small loops along the bottom edge of the tent. The pitching procedure then varies according to the design of the tent. If the tent has an interior frame, the frame is erected and the fabric draped over it. A tent with an exterior frame has hangers to which the fabric is attached. The fabric should be stretched enough to eliminate large wrinkles, but not so tightly that it will rip.

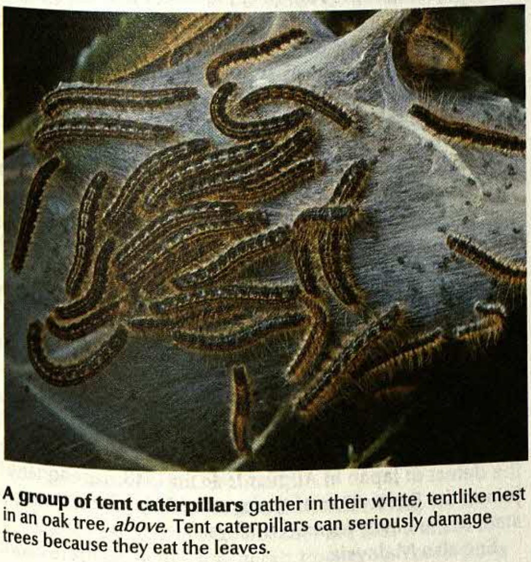
Wall tents and some A-frame tents are staked with ropes called *guy ropes.* The guy ropes of a wall tent are staked several feet from the tent. They are strung through holes along the top edges of the walls of the tent. Some A-frame tents have a guy rope attached to the top of the tent at each end. Guy ropes can be adjusted to assure the proper shape of the tent and tightness of the fabric.

Caring for a tent. A tent that receives proper care will provide years of use. The most important points in caring for a tent are to keep it as clean and dry as possible. Dirt, insects, and leaves should be wiped off the shelter each time it is taken down. If the tent is wet, it should be pitched and dried as soon as possible to avoid mildew and discoloration. After a camping trip, a tent should be thoroughly cleaned and dried before storage. Canvas and nylon tents can be washed in a mild detergent. Poles and stakes should not be packed with the tent fabric because they could puncture it.

See also **Camping.**

Tent caterpillar is the *larva* (second stage in the life cycle) of certain North American moths that damage trees. Tent caterpillars get their name from the fact that most species spin loose, white, tentlike webs in the forks of trees. The caterpillars crawl from this tent to feed on leaves.

In midsummer, the female tent caterpillar moth lays egg masses of 150 to 350 shiny brown eggs. The larvae hatch from the eggs the following spring. After four to six weeks, the larvae migrate from the tree to find a protected place, such as beneath fallen leaves or branches. There, they spin silky, white cocoons and enter the *pupa stage.* After 10 days to 2 weeks, pale brown moths emerge from the cocoons.



A group of tent caterpillars gather in their white, tentlike nest in an oak tree, *above.* Tent caterpillars can seriously damage trees because they eat the leaves.

Tent caterpillars damage trees because they eat the leaves. A nest of these caterpillars can eat all the leaves on a small tree and kill it. Tent caterpillars can be controlled by collecting their egg masses or by burning the larvae in their tents.

Scientific classification. Tent caterpillars are larvae of moths in the tent caterpillar moth family, Lasiocampidae. They are in the genus *Malacosoma.*

Tentacle is a slender, flexible growth on the head or around the mouth of certain animals. Tentacles are ordinarily used for protection or as feelers. Sea anemones and jellyfish use tentacles to capture food.

See also **Cnidarian; Jellyfish** (with pictures); **Squid; Animal** (picture); **Mollusc** (Univalves or gastropods).

Tenzing, Norgay. See **Mount Everest.**

Teotihuacan. See **Pyramids** (American pyramids; picture).

Tepee, also spelled *tipi,* was the type of tent most commonly used by the Plains tribes of North American Indians. A tepee was made by stretching a buffalo-skin covering over poles. The poles were arranged in the shape of a cone. At the top, the ends of the poles crossed and stuck out of the covering. Two flap "ears" were opened at the top to let out smoke from the campfire. The tent was pegged to the ground all around the bottom. The front had a slit partly closed with wooden pins to form an entrance.

See also **Indian, American** (pictures); **Tent; Wigwam.**

Tephra. See **Volcano** (Rock fragments; Kinds of volcanoes).

Terbium is a chemical element with the symbol Tb. It is one of the rare-earth metals. Its atomic number is 65, and its atomic weight is 158.925. Swedish scientist Carl Mosander first discovered terbium in 1843. Georges Urbain of France first isolated it in an almost pure form in 1905. Terbium is best separated from the other rare earths by ion-exchange processes or by solvent extraction. It has a density of 8.253 grams per cubic centimetre at 25° C. Terbium resembles silver in appearance. It melts at about 1365° C and boils at 3230° C. Chemists believe that terbium has a valency of 3 in most compounds. The dark-brown oxide (Tb_4O_7) becomes the white oxide (Tb_2O_3) when heated in a stream of hydrogen. Terbium salts are white with a slight pink cast. Many terbium compounds glow with a green colour and are used in phosphors.

See also **Element, Chemical; Rare earth.**

Terek River. See **Caspian Sea.**

Terence (195?-159? B.C.) was a Roman comic playwright. His plays are essentially Latin versions of Greek plots, more refined than those of Plautus and marked by pure style, careful construction, and fine characterization. All six of his comedies survive. They are *The Woman of Andros, The Self-Tormentor, The Eunuch, Phormio, The Mother-in-Law,* and *The Brothers. The Brothers* is a thoughtful comedy about two brothers, a country man and a city man. Each brings up one of the sons of the country brother. The country man is strict and the city man is permissive. The resulting idea, that education must pay attention to human nature, perhaps reflects Terence's own experience.

Terence was born Publius Terentius Afer in Carthage. He went to Rome as a slave in the household of a senator who educated and freed him.

Terengganu is a state on the east coast of Peninsular Malaysia. Kelantan lies to the northwest and Pahang to the southwest. Terengganu has a long coastline facing the South China Sea.

People and government. More than 94 per cent of the population is Malay, 5 per cent is Chinese, and 0.5 per cent is Indian. During the period of British rule, Terengganu did not experience the rapid economic change and mass immigration of Chinese and Indians in the same way as the other states of Peninsular Malaysia. This lack of immigration was because the region possessed no major deposits of tin and because its communications were poor.

The head of state of Terengganu is a *sultan* (ruler). The state assembly has 32 seats. See **Malaysia, Government of.**

Economy. The most important commercial crop is palm oil. The state also has large areas of rubber plantations. There is some rice cultivation. In the coastal settlements, many communities depend on sea fishing.

During the 1980's, large-scale petroleum plants were established off the Terengganu coast. On-shore facilities were developed to serve this new industry. There are several industrial estates in the coastal area.

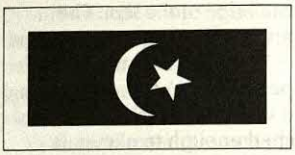
Land. Mountain ranges stretch along most of Terengganu's land borders with Kelantan and Pahang. Historically, these mountains have isolated Terengganu from the other states in the peninsula. The state has no rail links with the peninsula railway network, which was constructed during the period when the area was part of a British colony. The main roads enter the state at the low-lying coastal borders with Kelantan in the north and with Pahang to the south. Within the state the main road runs along the coast.

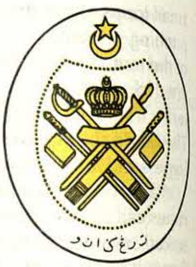
A considerable number of small rivers flow out of the mountain ranges to the west and drain into the South China Sea. The river valleys are fertile, but elsewhere in the interior the land is poor. The coast of Terengganu consists of curving sandy beaches, lagoons, and low, rocky headlands.

Facts in brief about Terengganu

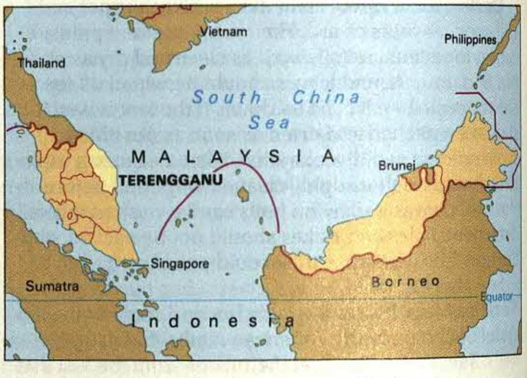
Population: *1991 census* 770,931.
Area: 12,955 km^2.
State capital: Kuala Terengganu.
Largest cities: Kuala Terengganu, Kuala Dungun, Kemaman.
Chief products: *Agriculture*—palm oil, rice, rubber. *Mining*—natural gas, petroleum.

The leatherback turtle lays eggs on the beaches of Terengganu in the summer. This species grows very large.





The flag of Terengganu features the crescent and star, the symbols of Islam. On the emblem, *right,* are symbols of Malaysian royalty. They symbolize the authority and responsibility of the state and its ruler.



Terengganu is a state on the east coast of Peninsular Malaysia. Its main products are palm oil, petroleum, and rubber.

History. The modern history of Terengganu dates from the 1300's when a local ruler converted to Islam. This conversion occurred well before the rise of Melaka. The evidence for the conversion is the inscribed Terengganu Stone. It is possibly the oldest Malay text written in the Arabic script. In the late 1400's and early 1500's, the region came under the rule first of Melaka and then of Johor. But for geographical reasons the state was more subject to pressure from the Thai kingdoms to the north. Through much of the 1800's, Terengganu sent *tribute* (payment) to Bangkok, although in practice the Thai rulers had little real authority over the area. By 1900, British influence in the peninsula had begun to threaten Thai claims over the state. In 1909, the Thai administration in Bangkok renounced its claims and transferred Terengganu, together with Kedah, Kelantan, and Perlis, to British authority.

During the colonial period, British administration was less strict in Terengganu than in the states on the west coast. This was largely because it appeared to have only a limited economic potential. As a result, the Terengganu ruling class remained largely independent.

In August 1943, the invading Japanese allowed Thailand to *annex* (take over) Terengganu, together with Kedah, Kelantan, and Perlis. The annexation ended with the defeat of Japan in August 1945. In 1948, Terengganu joined the Federation of Malaya. In 1963, it became a state of the newly formed Malaysia.

See also **Malaysia.**

Mother Teresa

Teresa, Mother (1910-), is a Roman Catholic nun who received the 1979 Nobel Peace Prize for her work with the poor. She is known as the *saint of the gutters.* In 1950, Mother Teresa founded a religious order in Calcutta, India, called the Missionaries of Charity. The order provides food for the needy and operates hospitals, schools, orphanages, youth centres, and shelters for lepers and the dying poor. It has branches in about 50 Indian cities and about 30 other countries.

Mother Teresa's original name was Agnes Gonxha Bojaxhiu. She was born in what is now Skopje, Macedonia, of Albanian parents. In 1928, she joined a religious order, which sent her to India. She took the name *Teresa* after joining the order. A few years later, she began teaching in Calcutta. In 1948, the Catholic Church granted her permission to leave her convent and work among the city's poor people. She became an Indian citizen that year.

In addition to the 1979 Nobel Peace Prize, Mother Teresa has received other awards for her work with the needy. These awards include the Pope John XXIII peace prize, which she received in 1971, and India's Jawaharlal Nehru award for international understanding, given to her in 1972.

Teresa, Saint (1515-1582), also spelled *Theresa,* is a saint of the Roman Catholic Church. She was a Spanish nun, and is one of the patron saints of Spain.

Saint Teresa was born in Avila in Old Castile, Spain. Her study at an Augustinian monastery and her reading of the tales of ancient martyrs inspired her to seek martyrdom for herself. In 1533, she entered a Carmelite convent. The lack of asceticism and severity displeased her, but for many years she made no attempt to bring about reforms. A reading of the *Confessions* of Saint Augustine, combined with the death of her father and certain supernatural visitations, wakened in her a strong spirituality. She began to feel that it was her duty to restore the Carmelite order to the original austerity of its rule. Accordingly, she withdrew with a few followers in 1562, and set up a new convent to put her ideas into effect. Opposition to her plan was strong, but the pope approved of the idea. At last, the general of the order asked her to introduce her reforms into other convents. She opened many new convents in Castile and even beyond its boundaries, and accomplished much in her efforts to reform existing Carmelite houses.

Several cities contended for her body after her death in Alba de Tormes, near Salamanca. The power of working miracles was believed to be in her relics, which were carried to various places. She was canonized by Pope Gregory in 1622. Saint Teresa wrote an autobiography and several treatises and letters, all published in 1587. Her feast day is October 15.

Tereshkova, Valentina Vladimirovna, (1937-), a Soviet cosmonaut, became the first woman to travel in space. In the spacecraft *Vostok VI,* Tereshkova made 45 revolutions around the earth in a 70-hour and 50-minute flight from June 16 to 19, 1963. Soviet cosmonaut Valery F. Bykovsky was in orbit at the same time. He was launched almost two days before Tereshkova. The two spacecraft came within 5 kilometres of each other during the flight. Soviet officials said the dual flight was conducted for "simultaneous observation of the reactions of a man and woman flying in space."

Valentina Tereshkova

Tereshkova orbited the earth once every 88 minutes during her historic journey. The *apogee* (highest point in the orbit) carried her about 209 kilometres above the earth. The *perigee* (lowest point in the orbit) was approximately 174 kilometres above the earth. Tereshkova operated her spacecraft by manual controls.

Tereshkova parachuted from *Vostok VI* after reentering the earth's atmosphere. She landed approximately 612 kilometres northeast of Karaganda, Kazakhstan, in central Asia.

Tereshkova was the first space traveller with no previous experience as a test pilot. She became interested in parachuting as a hobby, and made more than 125 jumps before volunteering for space flight training school. At the school, Tereshkova also received training as an aeroplane pilot.

Tereshkova was born in the village of Maslennikovo, near Yaroslavl, in western Russia. She went to work in a textile mill when she was 18 years old. Tereshkova became an active member of the Young Communist League while at the mill. In November 1963, she married cosmonaut Andrian G. Nikolayev.

See also **Astronaut** (The cosmonauts).

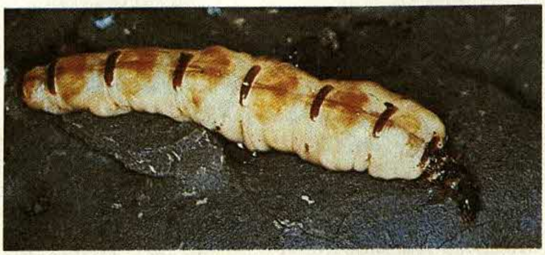
Terman, Lewis Madison (1877-1956), was an American psychologist who became known for his studies of intelligence. In 1916, while teaching at Stanford University in California, U.S.A., Terman revised the Binet-Simon intelligence tests, which were in French, for English-speaking students. The revised examination, usually called the Stanford-Binet test, became one of the most widely used tests of learning ability. Terman worked with Maud A. Merrill, another Stanford psychologist, on two later revisions of the test, published in 1937 and 1960.

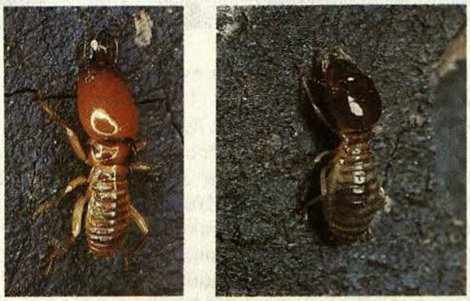
Terman was especially interested in children of high intelligence. In the early 1920's, he began a study of the behaviour and personality of about 1,500 extremely gifted students. He observed them throughout their careers and reported on their development. Terman's study helped prove that most gifted children are normal and well adjusted. The reports of his study were published in a five-volume series, *Genetic Studies of Genius* (1925-1959).

Terman was born in Johnson County, Indiana, U.S.A. He taught at Stanford from 1910 to 1942.

See also **Intelligence quotient** (History).

Termite is the common name of a group of insects that live in communities somewhat as ants do. They have





Termites live in colonies where each *caste* (group) has a certain job. The queen, *top,* is a fully developed female whose sole job is to mate and reproduce. The soldier, *bottom left,* defends the colony against attack. The worker, *bottom right,* gathers food and cares for the young termites after they hatch.

A termite nest may contain thousands of termites. It is made of wood particles and divided into chambers.

long been known as *white ants.* This name is incorrect, for termites are like ants only in their habits of living together and in their small size. Actually, termites are more closely related to cockroaches and grasshoppers. Their mouth parts, antennae, thick waists, primitive wings, and other features resemble those of cockroaches. Ants have thin waists and elbowed antennae.

Life and habits. There are three *castes* (groups) in most termite colonies. Some reproduce, others are workers, and still others are soldiers. The highest is the *royal* or *reproductive* caste. This is made up of fully developed males and females. Of all the termites, these most closely resemble other insects. They are dark coloured and have eyes, fairly hard bodies, and fully developed wings. Each colony of termites is founded by a pair of reproductives, which become the king and queen of the colony. Other and less completely developed kings and queens often develop in older colonies. In every mature colony, also, there develops an annual population of young winged reproductives that leave the parent nest, mate, and set out to start new colonies. They use their delicate, membranous wings for one short flight. They shed their wings immediately afterward and just before they seek mates.

The *worker* caste consists of small, blind, wingless termites with pale or whitish soft bodies. Only the heads and feet of the workers are covered with a hard protective material. The workers are the most numerous individuals in a colony. They do all the work. They enlarge the nest, search for food and water for the colony, and make tunnels.

The *soldiers,* which are also wingless and blind, are larger than the workers. They have enormous hard heads, powerful jaws, and strong legs. Their bodies are soft and weak. The sole duty of the soldiers is to defend the termite colony against attack, which comes principally from ants. The soldiers are strangely unable to care for themselves. They must be fed and groomed by the workers.

All termite castes contain both sexes, and the kings live as long as the queens, up to 50 years in some species. In wasp, ant, and bee colonies, *drones* (males) appear only in the reproductive caste and live for only a short time.

Termite eggs and newly hatched young appear to be alike in all the castes. Why some young develop into workers and others into soldiers or reproductives has not been entirely settled. With certain termites it seems development is governed by substances that are contained in skin secretions produced by the reproductives and soldiers. The workers lick off the secretions as they groom the reproductives and soldiers. These skin secretions are also given with food to the entire colony of termites.

Termites live most abundantly in warm regions, notably in Africa, Australia, and the Amazon regions of South America. Some termites build huge mounds of bits of soil mixed with saliva. These nests may be as much as 6 metres high. Termites seldom venture out into the open. Their pale colour indicates a lack of protective pigment. This means that bright sunshine will kill them. They build underground tunnels to their food sources. When they have to move about above ground, they make covered runways.

The inside of a termite mound is divided into numerous chambers and galleries. In the centre is a closed cell, where the king and queen are kept. In the cell, the female undergoes an extraordinary change. Her body swells until it is large enough to hold many thousands of eggs, sometimes as long as 10 centimetres. The queen lays the eggs at the rate of several thousand a day. The worker termites carry the eggs away to specially constructed cells in the nest. There the workers take care of the *larvae* (young) of the termites as they hatch from the eggs.

Termites digest wood, paper, and other material containing cellulose, with the aid of protozoa in their bodies. They do much damage in tunnelling through the woodwork of houses, destroy books and furniture, and do great damage to sugar cane and orange trees. In tropical forests, where these insects occur in large numbers, railway builders must import cast-iron or steel sleepers at great expense because the termites destroy wooden sleepers.

Kinds of termites. About 2,000 different species of termites are known. Only two species live in Europe. About 40 species live in North America. Australia has about 250 species.

North American termites fall into three groups, according to their habits. The *subterranean termites,* the smallest but most destructive, nest underground. They extend their burrows for considerable distances into wooden structures. The *damp-wood termites* live only in very moist wood. The *dry-wood termites* need little moisture. Damp-wood and dry-wood termites have no true worker caste.

The *magnetic termites* of northern Australia build unusual nests. The termites are called magnetic because the long axis of each slender nest points to the north magnetic and south magnetic poles. The broad sides of the nest are usually more or less the eastern and western sides. Scientists believe that the termites align their nests this way because this arrangement provides a large surface area for heat exchange. This assists the termites in maintaining a more comfortable environment within the nest. Some of the more advanced species of Australian termites have developed a remarkable habit of making a special bed of material on which certain types of fungus thrive. The termites grow these fungi and feed on them.

Termite control. Experts in countries in which termites are to be found recommend the use of stone, brick, or concrete for foundations of bridges and trestles, and for support posts of buildings. Where timber has to be used, it should be treated with creosote or other wood preservative applied in large tanks under pressure, to make sure it penetrates the wood deeply. Most termites will die if their supply of moisture is cut off.

Scientific classification. Termites make up the order Isoptera. This order includes the families Mastotermitidae, Hodotermitidae, Kalotermitidae, Rhinotermitidae, and Termitidae. The family Rhinotermitidae includes *Reticulitermes,* the most important genus in the order.

Tern is a subfamily of sea birds related to gulls. Terns are famous for their powers of flight. About 35 or more kinds of terns are found in different parts of the world. Most of them live along seacoasts, rivers, and lakes, rather than in the open sea. The *sooty tern* and some others often range far from land.

Terns have long, pointed bills, and webbed feet. Their pointed wings can carry them through the air swiftly and for long distances. Their swift, graceful flight has given them their popular name of *sea swallow.* Terns feed mainly on small fish. They seize the fish by darting quickly into the water from the air, with the bill pointing down.

The Caspian tern has a black crest and grey feathers. Terns have pointed wings that can carry them over long distances.

Great colonies of terns inhabit islands during the nesting season. Usually, the nests are slightly hollowed-out places in the ground. Sometimes, the terns lay eggs on bare rock or sand. Some make nests of seaweed. The *fairy tern* lays its single egg on a hollow place on a small branch, or on a rock ledge with no nest whatever. The parents then carefully incubate the egg by sitting on it until it hatches.

One of the largest kinds of terns is the *Caspian tern,* a handsome bird about 53 centimetres long. It has a shining black crest, and pearl-grey back and wings. The smallest tern is the *little tern,* about 23 centimetres long. Large numbers of the beautiful *common tern* live in northern Europe, Asia, and along the Atlantic Coast of North America. Once hunters almost killed off this species in seeking its eggs and plumes. Terns are now protected by law in some countries. The common tern has light, pearl-grey feathers, with a white tail and throat. It is about 38 centimetres long. The common tern lays three or four eggs, which range in colour from whitish to brownish and are thickly spotted with brown and lavender. Other types of terns include the *black, gull-billed, royal,* and *arctic terns.* The arctic tern flies farther in its migration than any other bird known. Some arctic terns travel more than 35,000 kilometres in a year, from the Arctic Circle to the Antarctic Circle and back. See **Arctic tern.**

Scientific classification. Terns are in the gull family, Laridae, and make up the subfamily Sterninae. Most of them are genus *Sterna,* including the sooty tern, *S. fuscata;* the little tern, *S. albifrons;* the common tern, *S. hirundo;* and the arctic tern, *S. paradisaea.* The fairy tern is *Gygis alba;* the Caspian tern, *Hydroprogne caspia;* the black tern, *Chlidonias niger;* the gull-billed tern, *Gelochelidon nilotica;* and the royal tern, *Thalasseus maximus.*

Terpsichore. See **Muses.**

Terracing. See **Conservation** (Soil conservation); **Philippines** (picture: Traditional and modern ways of life).

Terracotta, is a hard, durable kind of earthenware. Like other kinds of earthenware, terracotta is a type of baked clay. It ranges in colour from buff to brown to various shades of red and is usually unglazed. Terracotta is widely used to make flowerpots, fountains, tiles, architectural ornaments, and decorative garden sculptures. Because terracotta can be moulded easily, many sculptors have used the material to make preliminary models.

Terracotta was developed during prehistoric times. The ancient Greeks and Romans used the material to make decorative objects, plus gutters, pipes, and other construction materials. The term *terracotta* is Italian for "cooked earth."

Enamelled sculpture (early 1500's) by Andrea della Robbia; Bargello, Florence, Italy

Terracotta sculpture

The diamondback terrapin gets its name from the shape of the pattern on its shell. This small turtle makes its home in fresh waters and salt marshes of North America.

Terrapin is the common name of some freshwater turtles of the United States. The best known species is the *diamondback terrapin,* which lives along the Gulf Coast, and along the Atlantic coast south of Massachusetts. It lives in salt marshes and feeds on green plants, snails and other water animals. The female is larger than the male and grows up to 18 centimetres long. In parts of the southeastern United States, people catch diamondback terrapins for food. Many are also killed by cars on coast roads. Other freshwater turtles, known as cooters and sliders, are also sometimes called terrapins.

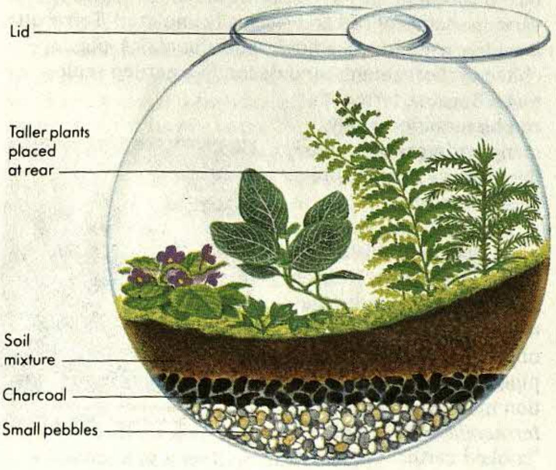
Scientific classification. Terrapins belong to the freshwater turtle family, Emydidae. The diamondback terrapin is *Malaclemys terrapin.* Cooters and sliders belong to the genus *Pseudomys.*

Terrarium is the name for a transparent container in which small plants or small land animals are kept. Terrariums reproduce as closely as possible a natural setting or habitat. People set up terrariums in glass or plastic containers of various sizes and shapes. The containers are usually covered to prevent the loss of moisture. The word *terrarium* comes from a Latin word that means *earth.*

To prepare a terrarium, place a layer of small pebbles on the bottom of the container for drainage. A layer of broken charcoal should be added to absorb odours and to provide additional drainage. Then add commercial potting soil or a mixture made up of garden loam, freshwater sand, and either peat moss or *leaf mould* (decomposed leaves). This mixture should be heated in an oven at 93° C for one hour to kill harmful bacteria and other soil pests. When the mixture is cool, place it into the container, handful by handful.

How to make a terrarium

A terrarium can be made by placing pebbles, charcoal, and a soil mixture in a transparent container. Then add such plants as ferns and ivy which grow well in a warm, humid atmosphere.



Plants that grow well together under the same conditions are best suited for a terrarium. Each plant should be carefully placed in the soil leaving enough space between plants to allow for growth. The soil should be moistened thoroughly, but not so much that it becomes soggy. Animals often kept in terrariums include lizards, small snakes, toads, and salamanders.

The completed terrarium should be placed in an area that is well-lit but out of direct sunlight. When covered, a balanced terrarium preserves temperature and moisture inside to provide excellent growing conditions. If the container clouds with moisture, the lid may be opened to decrease humidity.

Terrier is the name of a group of breeds of dogs. The name comes from the Latin word *terra,* meaning *earth,* because these breeds were once used to drive game out of holes, or burrows, in the ground. Most terriers originated in England.

The 24 recognized terrier breeds are the *Airedale terrier, American Staffordshire terrier, Australian terrier, Bedlington terrier, border terrier, bull terrier, cairn terrier, Dandie Dinmont terrier, Irish terrier, Kerry blue terrier, lakeland terrier, Manchester terrier, miniature schnauzer, Norfolk terrier, Norwich terrier, Scottish terrier, Sealyham terrier, Skye terrier, smooth fox terrier, soft-coated wheaten terrier, Staffordshire bull terrier, Welsh terrier, West Highland white terrier, and wire fox terrier.* Four other breeds are called terriers, but are not members of the terrier group. The *Boston terrier* and the *Tibetan terrier* are classed as nonsporting dogs. The *Silky terrier* and the *Yorkshire terrier* are toy dogs. All the terrier breeds have separate articles in *World Book.*

See also **Dog** (table; pictures: Terriers).

Territorial waters are areas of the sea where a nation has *sovereign rights.* These rights include control of fishing, navigation, and shipping, as well as the use of the sea's natural resources.

A nation's territorial waters include its *internal waters* and its *territorial sea.* Internal waters include lakes, rivers, and the waters within such coastal areas as bays and gulfs. A country's territorial sea lies beyond its coast or the boundary of its internal waters. Nations have more authority over their internal waters than their territorial seas. The main difference is that ships of other countries can freely cross territorial seas in peacetime.

Various nations have set different outer limits for their territorial sea. Most of the approximately 120 coastal nations have a limit of 12 or fewer nautical miles. A nautical mile equals about 1.9 kilometres. A few nations claim a limit of as much as 200 nautical miles. Many countries prohibit foreigners from fishing in their territorial sea. Many nations also claim exclusive fishing and other rights in an *exclusive economic zone,* which extends 200 nautical miles from shore.

The United Nations sponsored a series of conferences to draw up an international treaty governing many uses of the sea. In 1982, a Law of the Sea Treaty was approved by 117 nations. Among other things, the treaty provides for a territorial sea of 12 nautical miles. It will not become official until ratified by 60 nations, but most of its terms are already being followed.

See also **High seas.**

Territoriality is a form of animal behaviour in which an individual animal or a group claims a certain area as its own. Such animals also defend the territory against other members of their species. Some animals hold long-term claims on large territories that they use as sources of food. Other species become territorial only during their breeding season, when they defend a small nesting area. Territoriality is most common among birds, fish, and lizards. Some species of amphibians and mammals also claim territories. Few invertebrates do so.

Animals claim territories in various ways. Songbirds establish their areas by vigorous singing. Some mammals signal territorial claims by leaving scents, such as that of urine or of secretions from special glands.

Various species also differ in how they defend their territories. Male fur seals fight intensely during the breeding season. Some fish push against each other until one retreats. But most animals rarely engage in physical combat. Instead, they make threatening movements to ward off intruders. For example, fiddler crabs signal their territorial rights by waving their large claw. The colour of some fish brightens when they are in their own territory but fades rapidly if they swim away.

Territoriality serves different purposes among different kinds of animals. It may protect a female from males other than her mate. Or it might provide a male and a female a good nest site and a feeding area large enough to support their young. Among many species, individual animals without a territory do not breed. Thus, territoriality may prevent the population from becoming too large for the environment.

See also **Animal** (Animal homes; Communication); **Mammal** (Territoriality).

Territory is a type of region that belongs to or is controlled by a country or other independent political unit. In countries with a federal government, such as Australia, Canada, India, Mexico, and the United States, territories generally have less power than states or provinces. In these countries, the national government sets up separate governments for the individual territories. Sometimes, territories have no representation in the national government. They have varying degrees of self-rule, and may or may not become states or provinces. Some national capitals are in territories, including Canberra, in Australia, and New Delhi, in India.

See also **Australia, Government of; Canada; Enclave; Trust territory.**

Terrorism is the use or threat of violence to create fear and alarm. Terrorists murder and kidnap people, set off bombs, hijack aeroplanes, start fires, and commit other serious crimes. But the goals of terrorists differ from those of ordinary criminals. Most criminals want money or some other form of personal gain. But most terrorists commit crimes to support political causes.

The word *terrorism* first appeared during the French Revolution (1789-1799). Some of the revolutionaries who seized power in France adopted a policy of violence against their enemies. The period of their rule became known as the Reign of Terror.

Features of terrorism. Terrorist acts are committed for various reasons. Some terrorist groups support a particular political philosophy. Other terrorist organizations represent ethnic groups seeking liberation from governments in power. Dictators use violence to frighten or eliminate their opponents. Most terrorist groups have a small number of members. They believe the threat or use of violence to create fear is the best way to gain publicity and support for their causes.

Generally, terrorists attack people who oppose their cause or objects that symbolize such opposition. Common victims of terrorist kidnappings and assassinations include diplomats, business executives, political leaders, judges, and police. Terrorists also attack churches, synagogues and other places of worship, oil refineries, and government offices. At other times, terrorists simply choose any target certain to attract newspaper or TV coverage. Some terrorists hijack aeroplanes or seize public buildings. Then they hold the passengers or occupants hostage and make demands to further their cause. They often threaten to kill the hostages if their demands are not met. Bombings make up about half of all terrorist acts.

Terrorism may cross national boundaries. A quarrel in one nation may produce terrorist attacks in several other countries. Some governments secretly support certain terrorist groups by providing weapons, training, and money for attacks in other countries.

Most terrorist groups fail to achieve their long-range political goals. Governments fight terrorism by refusing to accept terrorist demands and by increasing security at airports and other likely targets. Some countries train special military units to rescue hostages.

History of terrorism. Terrorist tactics have been used for hundreds of years. An American group, the Ku Klux Klan, used violence to terrorize blacks and their sympathizers after the end of the American Civil War in 1865 and during the 1900's. In the 1930's, the dictators Adolf Hitler of Germany, Benito Mussolini of Italy, and Joseph Stalin of the Soviet Union used terrorism to discourage opposition to their governments.

Another wave of terrorism began during the 1960's. Terrorist groups that surfaced included the Red Brigades in Italy and the Red Army Faction in West Germany. Both groups sought the destruction of the current political and economic systems in their home countries and the development of new systems. Before the independence of Israel in 1948, a Jewish group used terror to speed the end of British rule in Palestine and create a

Wreckage of a terrorist bombing, *left,* of an aeroplane was scattered over Lockerbie, Scotland in 1988.

Jewish homeland. Since the 1960's, various Palestinian groups have carried out a campaign of terrorism aimed at the destruction of Israel and the establishment of an independent Palestinian state.

In Northern Ireland, Roman Catholic and Protestant extremists have used violence to push for, respectively, the end of, or the continuation of, British rule. Terrorists from many other countries around the world continued their campaigns into the 1990's.

See also **Anarchism; French Revolution** (Terror and equality); **Guerrilla warfare; Hostage; Ku Klux Klan.**

Terry, Dame Ellen (1847-1928), was a leading English actress especially noted for her performances as Shakespearean heroines. Terry was associated with actor and theatre manager Sir Henry Irving.

Terry and dramatist George Bernard Shaw exchanged letters about the theatre of their time for more than 25 years. Their correspondence, *Ellen Terry and Bernard Shaw,* was published in 1931. She also wrote an autobiography, *The Story of My Life* (1908). Terry's *Four Lectures on Shakespeare* was published in 1932.

Ellen Alice Terry was born in Coventry. She first appeared on stage at the age of 9 in Shakespeare's *The Winter's Tale.* She lived with Edward Godwin. They had two children who had prominent theatrical careers—Edith Craig, an actress, and Edward Gordon Craig, a scenic designer. Terry was made Dame Grand Cross in the Order of the British Empire in 1925.

Tertiary Period. See **Earth** (table: Outline of the earth's history).

Tertis, Lionel (1876-1975), became famous as a viola player and designer of stringed instruments. He promoted the viola as a solo instrument and arranged pieces for it. He also commissioned viola compositions from such composers as Arnold Bax. Tertis improved the design of the viola and also redesigned the cello and violin. He was born in West Hartlepool, England. He studied at the Royal Academy of Music, in London, and at the Leipzig Conservatory, Germany.

Terrorists, *below,* have hijacked aeroplanes and taken the passengers hostage in order to make political demands.

Tesla, Nikola (1856-1943), an electrical engineer, is generally recognized as the inventor of the induction motor. While still a student, he began to devise a motor free of the inconvenience of the commutator. Tesla invented a motor with coils arranged so that when out-of-step alternating currents energized them, the resulting magnetic field rotated at a predetermined speed. See **Electric motor.**

Tesla patented the rotating field motor in 1888. He introduced it at a time when advocates of alternating current were seeking such a motor. He sold it to George Westinghouse, whose company developed it into a commercial motor.

Tesla made advances in the fields of high voltage and frequency apparatus. He invented the Tesla coil, a system of arc lighting, a generator for high-frequency currents, and a system of wireless transmission.

Tesla was born in Smiljan, Croatia (then part of the Austrian Empire). He received a technical education at an engineering college in Graz and at the University of Prague. He moved to France and went to the United States in 1884. After 1900, Tesla engaged in independent research in his laboratory.

Test. See **Testing; Drug** (Testing with people).

Test Acts. Certain religious laws passed by the English Parliament were known as Test Acts. The laws were intended to keep people who were not members of the Church of England from holding public office. One of the most important test acts was the Corporation Act of

1661, which stated that all judges must declare complete allegiance to the king and must receive communion according to the Church of England. The Test Act of 1673 made the same provisions for all other holders of public office. All test acts in Great Britain were finally repealed in 1828.

Test pilot is a person who flies new aircraft to test them for safety. There are two kinds of test pilots—experimental test pilots and production test pilots.

Experimental test pilots test the performance capabilities of newly designed aircraft. They become the first people to fly such aircraft. These pilots test the performance limits, called the *flight envelope,* of an aircraft by subjecting it to greater-than-normal flight stresses. Most experimental test pilots have at least a bachelor's degree in engineering, mathematics, or one of the physical sciences. The majority have also attended a military test-pilot school. Experimental test pilots know what to expect from an aircraft's design and what problems to anticipate. Most of these pilots have several thousand hours of flying time and can react calmly and quickly to unexpected situations.

Many U.S. astronauts and Soviet cosmonauts formerly served as experimental test pilots. Charles E. Yeager, an American experimental test pilot, became the first person to fly faster than the speed of sound.

Production test pilots test factory-produced aircraft before the aircraft are delivered to customers. The pilots make sure that the aircraft's engines, flight controls, and mechanical systems are functioning properly. The design of the aircraft has already passed through the experimental flight-testing phase. Production test pilots typically have a strong understanding of aircraft mechanics.

See also **Aeroplane** (Design and testing).

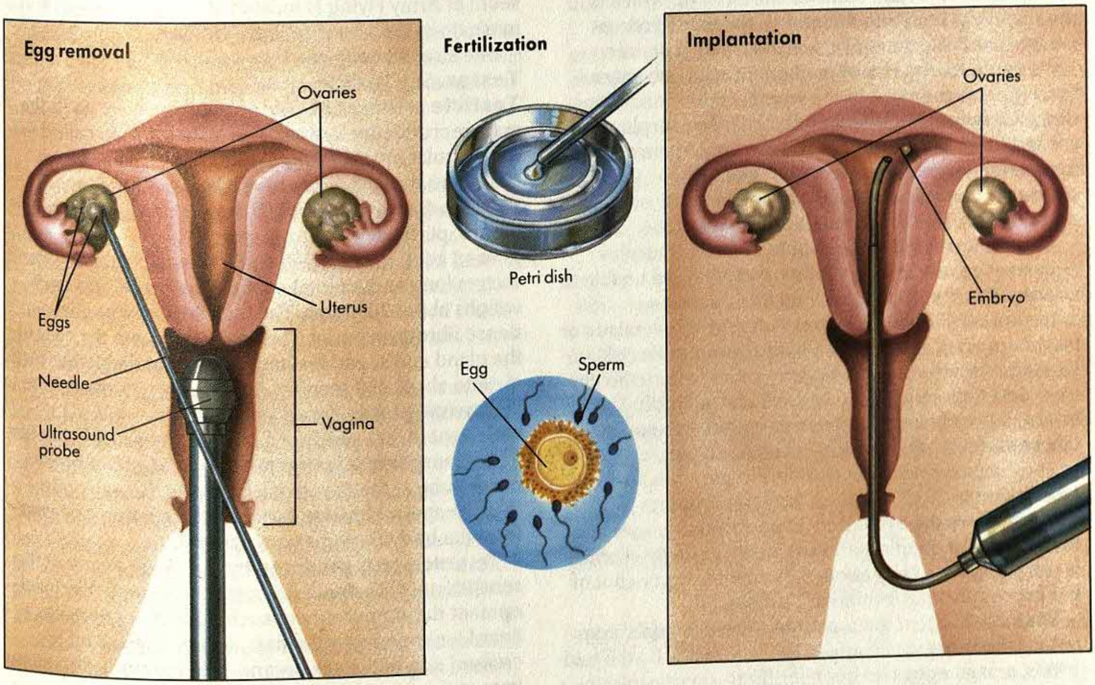
Test tube baby is the popular name for a baby resulting from *in vitro fertilization* (IVF). In vitro fertilization involves the fertilization of a human egg cell in a laboratory and the implantation of the *embryo* (fertilized egg) inside a woman's *uterus* (womb) for a normal pregnancy and birth. Sometimes, an embryo resulting from in vitro fertilization is frozen for later implantation.

In vitro fertilization is a method of impregnating women who normally have difficulty achieving pregnancy. The method can also be used to avoid the transmission of certain inherited diseases. Fertilization takes place not in a test tube, but in a small glass receptacle known as a *Petri dish.*

Research has shown that infertility is on the increase in some industrial countries, and that either or both partners can be affected. Doctors can treat about two-thirds of infertile couples with drugs or surgery. Some of the remainder may be helped by IVF and related treatments.

Techniques. A number of steps are involved in producing a "test tube" baby. The first is the collection of ripe eggs from the woman. Before the eggs are collected, the woman takes special drugs that stimulate *ovulation* (the release of eggs). The drugs are given so that more than one egg will be available for collection, thus improving the chances of successful fertilization. The woman is then monitored through blood tests to determine the best time for removing the eggs.

When the eggs are ripe, a surgeon performs an oper-



In vitro fertilization begins with the collection of eggs. An ultrasound probe inserted into the vagina enables doctors to see the eggs on a monitoring screen. The eggs are sucked out by a special needle and then fertilized by sperm in a laboratory dish. The *embryo* (fertilized egg) is then placed in the *uterus* (womb) by means of a thin tube inserted through the *cervix* (neck of the uterus).

ation to remove them. The surgeon may use a *laparoscope* (a type of telescope) to identify the eggs. The woman is given a general anaesthetic, and a small cut is made below her navel. This provides an opening large enough to allow the doctor to place the laparoscope in position. When the eggs have been identified, the surgeon uses a special needle to remove them.

Other techniques may be used to collect the eggs. These include *ultrasound* (a form of sound waves), which is used to identify the eggs. With this method, only a local anaesthetic is necessary, and a cut need not be made. Instead, the ultrasound probe is inserted through the bladder or the vagina. The eggs are then collected. Using ultrasound, the surgeon sees a picture of the *ovaries* (egg-producing organs) on a screen rather than through a telescope.

The third phase of in vitro fertilization involves the fertilization of the egg and its development in the laboratory. After the eggs have been removed from the woman, they are taken straight to the laboratory, where they are placed in a special fluid for six hours. The man who is the woman's partner, or a male donor, then supplies a sperm specimen. This must take place about four hours after the eggs have been collected. The sperm must be specially treated by washing and incubation. They are then placed together with the eggs and left for about 18 hours. Following this procedure, the eggs are reexamined to see if fertilization has occurred. They are then returned to culture for another 24 hours.

Following the fertilization procedure, the grown fertilized egg, or embryo, is transferred to the woman's uterus. The doctor places an extremely thin tube through the *cervix,* the neck of the uterus, into the uterus itself. This tube contains the embryo, which is then gently placed into the uterus. No anaesthetic is needed for this procedure, which is fairly pain-free.

To minimize the risk of multiple pregnancy, only a few eggs are returned to the womb. In the United Kingdom, the recommended limit is three. Any surplus eggs are fertilized and stored at sub-zero temperatures ready for use on another occasion. The "freeze-thaw" technique, using eggs which have been stored by cryopreservation, was first used in Australia in 1984.

In some cases, with the couple's consent, surplus eggs may be offered to other women who are unable to ovulate. The donor eggs may be fresh or frozen.

In vitro fertilization is in many ways controversial, not least because it is associated with considerable risk, including miscarriage, *ectopic* pregnancy (where the embryo develops outside the womb), and stillbirth. There is also a greatly increased risk of multiple pregnancy, where serious complications are more likely.

The success rate for in vitro fertilization ranges from 10 per cent to 20 per cent, according to reports from centres where the procedure is performed. However, the number of couples who eventually have live babies is extremely low. Only about 3 per cent to 5 per cent of the procedures performed are successful.

History. The first attempt to fertilize mammals' eggs in the laboratory was made in the late 1800's. By the mid-1900's, animal eggs had been fertilized successfully in the laboratory. In 1971, two British doctors, Robert Edwards and Patrick Steptoe, published an account of the first human *blastocyst* (preembryo) observed after fertilization in a glass dish. Seven years later, Edwards and Steptoe pioneered the world's first test tube birth. The world's first test tube baby, Louise Brown, was born in Oldham, England, in 1978. Australia's first test tube baby, Candice Reed, was born at Royal Melbourne Hospital in 1980.

In 1986, two babies that developed from frozen eggs were born in Adelaide. The babies' mother had suffered severe inflammation of her Fallopian tubes. The inflammation had damaged the tubes, which carry eggs from the ovaries to the uterus, and she had been unable to conceive. Three of the woman's eggs were collected, frozen, thawed, fertilized, and then implanted. Two fertilized eggs survived, and the pregnancy progressed without incident.

Moral objections to freezing embryos continued because some embryos have died in the process. Many people believe that a fertilized egg is the beginning of life. The use of frozen unfertilized eggs instead of frozen embryos has resolved some of the ethical questions associated with the IVF programme. In 1987, the Roman Catholic Church issued a statement opposing the use of in vitro fertilization.

See also **Fertilization; Infertility.**

Test Valley (pop. 99,000) is a local government district in Hampshire, England. Andover is its administrative centre. It also includes the towns of Romsey and Stockbridge. The River Test flows through the district. Chalk hills rise in the west of Test Valley, with rolling downlands to the east.

Industries in the district include light engineering, printing, and tea blending. Thruxton has a motor-racing circuit. Romsey has a splendid Norman abbey. The Museum of Army Flying is located at Middle Wallop, and a museum of the Iron Age is at Andover.

See also **Hampshire.**

Testes. See **Testicle.**

Testicle is either of a pair of small oval glands in the male reproductive system. The testicles, also called *testes* (singular, *testis*), hang behind the penis in a sack called the *scrotum.* They have two main functions. (1) They produce sperm, and (2) they secrete male sex hormones, particularly *testosterone.*

In an adult man, each testicle measures about 4 centimetres long and about 3 centimetres wide, and each weighs about 20 grams. The testicle is covered by a dense fibrous material. This material enters the rear of the gland and separates into sheets that divide the testicle into about 250 sections. Each section contains one to four twisting tubes called *seminiferous tubules,* in which sperm are produced. Larger tubes inside the testicles transport the sperm to the *epididymis,* a highly coiled tube at the rear of each testicle. In the epididymis, the sperm develop further before being released from the body during sexual arousal.

Testosterone is produced by the tissue between the seminiferous tubules. Testosterone controls the development during puberty of such male characteristics as a beard, enlarged muscle mass, a deep voice, and increased size of the sex organs. This hormone also stimulates male sexual behaviour.

See also **Reproduction** (The male reproductive system; diagram: Human reproduction); **Penis; Prostate gland; Testosterone.**

Testimonial. See **Advertising** (Testimonials).

Testimony. See **Witness.**

Testing, in education and psychology, is an attempt to measure a person's knowledge, intelligence, or other characteristics in a systematic way. There are many types of tests. Teachers give tests to discover the learning abilities of their students. They also give tests to see how well students have learned a particular subject. Some tests help people choose a vocation, and other tests help them understand their own personality.

Standardized tests

Most printed tests taken by students and others are *standardized.* A test has been standardized after it has been used, revised, and used again until it shows consistent results and average levels of performance have been established. Firms that prepare standardized tests include information with them on how to give and score each test. The results of one person's performance may be compared with those of many others who have taken the same test. Most teachers also use *nonstandardized* tests that they make up themselves. The quality of a test is judged by three major standards: (1) validity, (2) reliability, and (3) practicality.

Validity reflects how well a test measures what it is intended to measure. For example, a test of reading comprehension could lose validity if it allows too little time for taking the test. It might actually measure reading speed rather than comprehension.

Reliability refers to the consistency of results achieved by the test. To establish reliability, a test may be given to the same group several times. If very similar results are obtained each time, the test may be considered highly reliable.

Practicality involves the cost and convenience of the test. If a test requires too much expense or effort, it may be impractical. It also may be impractical if the results are too difficult to interpret.

Kinds of tests

Most tests are designed to measure one of several characteristics: (1) learning ability, (2) learning achievement, (3) aptitude and interest, or (4) personality.

Tests of learning ability attempt to predict how well an individual will perform in a situation requiring intellectual ability. These tests are sometimes called *intelligence tests, mental ability tests, academic aptitude tests,* or *scholastic aptitude tests.*

A learning ability test consists of a standard set of tasks or questions. It enables a student to demonstrate the skills learned throughout the individual's life, both in and out of school. Tests of learning ability do not measure how "bright" a person is. Educators use the terms *intelligence* and *mental ability* simply to describe a person's ability to solve certain kinds of problems typically involved in schoolwork. These terms do not reflect a person's ability in all areas. See **Intelligence; Intelligence quotient.**

Achievement tests try to measure how much an individual has learned about a particular subject, rather than the general ability for learning. Schools use achievement tests more than any other kind of test. Throughout primary school, secondary school, and college, most teachers rely on such tests when rating a student's progress. Special achievement tests are used to licence people in such professions as law, medicine, and accounting.

Many teachers prepare achievement tests that closely follow their own method of instruction. They also use standardized achievement tests. Some schools ask students to take standardized achievement tests, as well as scholastic ability tests, for admission or placement.

There are two types of achievement tests—*norm-referenced* and *criterion-referenced.* In norm-referenced tests, each person's performance is compared with those of others who took the test. A student who answers some questions incorrectly would still rank highly if most other students answered a larger number of questions incorrectly. But in criterion-referenced tests, each person's performance is compared with a predetermined standard or criterion. For example, a teacher might decide that 90 per cent of the questions on a test must be answered correctly for a student to earn a passing grade.

Aptitude and interest tests reveal an individual's talents or preferences for certain activities. A person who likes to tinker with machinery would probably score highly on a test of mechanical aptitude. Such a person has an aptitude for mechanical work—and at least a fairly good chance of succeeding at it.

Interest tests are also known as *interest inventories.* In them, a person indicates his or her preferences among large groups of activities, ideas, and circumstances. One of these tests might ask, "Would you rather fix a broken clock, keep a set of accounts, or paint a picture?" Most individuals prefer certain types of activities over others. The pattern of answers reveals the strength of a person's interest in various fields.

Personality tests attempt to measure an individual's personal traits scientifically. Some standardized personality tests consist of lists of personal questions requiring yes or no answers. The answers can be analysed for various characteristics. For example, a person might score high in *social introversion,* which would indicate a strong preference for being alone. Such a person might find scientific research more satisfying as a career than teaching science in a classroom.

Another type of personality test, the *projective test,* requires individuals to tell what certain images mean to them. In a Rorschach test, for example, a person describes what he or she sees in a number of standardized inkblots. A trained counsellor can often recognize behavioural tendencies in these descriptions. Psychologists use personality tests as clues for further study of an individual. They do not regard them as conclusive evidence about the individual's personality. See **Personality.**

Most personality tests are less reliable and less valid than the other kinds of tests discussed here. Some people criticize their use as an invasion of privacy.

How to take a test

Knowing how to take tests does not increase anyone's learning ability or achievement. But it does help a person avoid losing points unnecessarily. Experts in testing offer the following suggestions:

1. Get all the experience you can in taking tests. The ability to take tests improves with practice.

SCHOOL LEARNING ABILITY TESTS

Verbal Reasoning

1. Which word below does *not* go with the others?
a) red b) green c) dark d) blue

2. Eye is to see as ear is to
a) head b) hear c) talk d) nose e) cheek

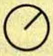
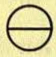
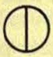
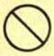
Quantitative Reasoning

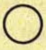
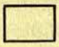
1. A boy bought 3 pencils at 5¢ each. How much did the 3 pencils cost?
a) 5¢ b) 10¢ c) 20¢ d) 25¢ e) none of these

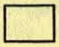
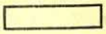
2. Which number is missing in this series?
1 2 _ 4 5 6 7
a) 1 b) 3 c) 4 d) 8

Figural Reasoning

1. Which picture does not belong with the others?

a)  b)  c)  d) 

2.  is to as  is to

a) b)  c) d) e) 

Learning ability tests measure intellectual skills that an individual has learned from a variety of sources, including the home, school, and community. These tests are used to estimate a student's capacity for learning. They can help teachers instruct the student better and direct the student toward kinds of learning that best suit individual abilities.

2. Cramming before a test is better than no study at all. But a careful review spread over several days is better than cramming.

3. Be sure you understand the directions at the beginning of a test. Otherwise, you may get a lower score than you deserve because you failed to follow certain instructions.

4. Answer the questions that are easy for you, and then go back to the hard ones.

5. If there is no penalty for guessing, answer every question. If there is a penalty, you may still gain points by guessing some answers. On a multiple-choice question, for example, you may know enough about the subject to eliminate some answers. If so, your chance of guessing the correct answer improves considerably.

Interpreting test scores

There are several points to keep in mind about test scores. First, a test reflects only a sample of a person's skill or knowledge, not everything about an individual. A test score can tell only how well the person performed on one particular test on one particular day.

Second, a score on a standardized test compares one person's performance with the performance of others. Such a comparison may provide useful information if all the people taking the test are alike in some important way. Most standardized tests give scores for persons of the same age or in the same class.

Third, every test score is an estimate rather than a precise measurement. To remind people of this, some scores are reported as bands rather than as a single number. The bands show the range in which a person's actual ability probably lies.

Testing often has far-reaching effects, and so it receives much attention from educators and social scientists. Criticism has been directed both at the limitations of tests and at their influence.

Some educators believe multiple-choice tests penalize a student who has an expert knowledge of a subject. Such a student may see flaws in the answer generally accepted as correct. Other critics say that standardized tests discriminate against disadvantaged and minority groups. These students may be unfamiliar with words, terms, and concepts used in the tests. To give these students an equal chance, educators have tried to prepare *culture-fair* or *culture-free* tests. Such tests might consist of pictures, symbols, and nonsense syllables that are equally unfamiliar to everyone taking the test. This type of test reduces the influence of cultural background on performance. Tests that use no words at all are called *nonverbal tests.*

The general effect of testing on education has also caused concern. Standardized tests sometimes lag behind educational thought and practice. If tests do not measure the content of new syllabuses, they may fail to encourage educational progress.

Many educators believe there is at least some truth in criticisms of tests. But they also know that testing is necessary in teaching. Tests can determine whether one method of teaching works better than another. Tests can also tell a teacher what help a student needs most. No better way has been found to determine how much students have learned, what they seem able to learn, and how quickly they might learn it.

Testosterone is one of a group of hormones that stimulate sexual development in male human beings. These hormones, called *androgens,* are produced primarily by the *testicles,* a pair of male sex glands (see **Testicle**). The ovaries in females and the adrenal glands in both sexes also yield small amounts of testosterone and other androgens.

During a boy's early teenage years, his testicles are stimulated by a hormone from the pituitary gland to secrete increasing amounts of testosterone, particularly during sleep. Testosterone enters the blood and acts on certain tissues in the body to cause various physical changes. These changes include growth of hair on the face and in the genital region, muscle development, deepening of the voice, and maturation of the sex organs. Testosterone also helps in the production of sperm by the testicles. After a man reaches old age, the testicles produce less testosterone. In adult females, testosterone contributes to the formation of *oestrogens* by the ovaries. Oestrogens are hormones necessary for female sexual development. See **Oestrogen.**

In many kinds of animals, testosterone influences male sexual behaviour. For example, some deer breed in the autumn. At this time, the testicles of male deer secrete large amounts of testosterone. As a result, the males spend much time pursuing females.

Drugs called *anabolic steroids* are made from testosterone. They are used by some athletes who feel such drugs increase strength and endurance. Most doctors believe the dangers of using anabolic steroids outweigh the benefits. See **Steroid** (The sex steroids).

See also **Elephant** (Musth).

Tetanus is a serious disease that affects muscles. It is also called *lockjaw* because severe *spasms* (violent muscle contractions) of the jaw muscles make it hard for victims to open their mouths.

Tetanus is caused by *toxins* (poisons) produced by a bacterium called *Clostridium tetani.* These germs thrive in dust and dirt, and need no air to live. They get into the body through breaks in the skin. Any dirt in a wound may contain tetanus germs. The germs grow quickly if no air gets to the wound.

Symptoms of tetanus usually start within several days or weeks after infection. The victim feels depressed, has headaches, fever, pain, and soon has trouble opening the mouth or swallowing. After a while, all of the body muscles tighten, and spasms may interfere with breathing. If not treated, the victim may die from asphyxiation.

Tetanus can be prevented. All wounds should be cleaned thoroughly. People may be immunized against infection with injections of *tetanus toxoid,* a substance made from specially treated toxins of the bacillus. But if tetanus develops, doctors treat the disease with antitoxin injections. People with severe tetanus may need to undergo a *tracheostomy.* In this operation, surgeons make an artificial opening in the patient's windpipe to help the patient breathe.

See also **Kitasato, Shibasaburo.**

Tetany is a condition associated with overexcitability and spontaneous activity of the nervous system. It is characterized by periodic muscle spasms and small, fluttering tremors. Affected body parts may tingle or feel numb. The hands are usually affected first, but spasms may later spread to the face, body, and throat. The spasms are only painful in severe cases. Tetany results from a deficiency of calcium salts or a chemical imbalance in the body.

Tetra is a type of small tropical fish that lives in rivers of South America and Africa. Tetras are also called *characins.* There are nearly 1,500 species of these fish. Tetras are popular aquarium fish because they can be raised in captivity and have beautiful colours. Most tetras grow up to 5 to 8 centimetres long and live 3 to 4 years.

Popular species for home aquariums include neon tetras, bleeding-heart tetras, cardinal tetras, and diamond tetras. The neon tetra has a brilliant blue stripe along the side of its body. The bleeding-heart tetra has a red splotch on the middle of its side. The cardinal tetra is deep-red on the sides and the belly. The diamond tetra has a bright silver colour.

Scientific classification. Tetras belong to the family Characidae. The neon tetra is *Paracheirodon innesi,* the bleeding heart tetra is *Hyphessobrycon erythrostigma,* the cardinal tetra is *Cheirodon axelrodi,* and the diamond tetra is *Moenkhausia pittieri.*

Neon tetras are popular aquarium fish.

Tetracycline is any of a family of antibiotics used to treat infections. The tetracyclines affect many kinds of bacteria and other microorganisms, including *rickettsias* (see **Rickettsia**). Doctors use tetracyclines to treat such diseases as typhus, trachoma, and genital tract diseases. They also use tetracyclines in the treatment of acne.

The first tetracycline became available in 1948. Since then, tetracyclines have been widely—and often inappropriately—used to treat a great variety of diseases. This widespread use caused many microorganisms to become resistant to the effects of these antibiotics. As a result, tetracyclines are no longer effective against diseases caused by these microorganisms.

All the tetracyclines fight most of the same microorganisms. They differ chiefly in how well they are absorbed by the body and in how long their effects last. Tetracyclines act by blocking the process by which bacteria make proteins. Although generally safe, tetracyclines can cause many side effects. For example, large doses of these antibiotics can seriously damage the liver and kidneys. In addition, tetracyclines can permanently discolour developing teeth. For this reason, doctors do not prescribe tetracyclines in treating children and pregnant women.

See also **Antibiotic.**

Tetraethyl lead is an ingredient added to petrol to improve the performance of engines. It is called an *antiknock additive* because it reduces the "knocking" or "pinging" sound that an engine makes. An engine knocks if the petrol in its cylinders begins burning too soon or too fast. The same conditions that cause knocking also reduce an engine's power and can damage the engine. A small amount of tetraethyl lead in the petrol corrects these conditions.

An engine that burns *leaded* petrol (petrol containing tetraethyl lead) gives off an exhaust that includes chemical compounds containing lead. These compounds pollute the air. They also destroy the effectiveness of *catalytic converters,* devices installed in cars to remove pollutants from car exhaust. Because of these problems, oil companies make *unleaded* petrol. They also have decreased the amount of tetraethyl lead in their leaded petrol. These unleaded and reduced-lead fuels contain a larger proportion of other ingredients that resist knocking. As a result, the amount of tetraethyl lead needed in these types of petrol is reduced or eliminated.

See also **Octane number; Petrol.**

Tetrahedron, in geometry, is a *regular pyramid* whose sides consist of four equilateral triangles. See **Pyramid.**

Tetzel, Johann (1465-1519), was a Dominican friar who sold papal indulgences in Germany in 1517. He declared that anyone who bought an indulgence could choose a soul to be freed from purgatory. Tetzel's claim led Martin Luther in 1517 to draw up his Ninety-Five Theses in protest (see **Luther, Martin**). Tetzel's action thus brought about the Protestant Reformation. Germans accused Tetzel of telling possible buyers of indulgences:

> When the coin in the coffer rings,
> A soul from purgatory springs.

Many Catholics criticized Tetzel for his vulgar conduct. He defended himself vigorously but clumsily.

Tetzel was born in Pirna, Germany. In 1504, he began his long career of selling indulgences.

Teuku Umar (1854-1899) was a chief in Aceh, northern Sumatra, Indonesia. At various times, he fought against and alongside the Dutch colonial invaders. He is now regarded as an Indonesian hero.

As head of the village of Datar, Teuku Umar fought against the Dutch from 1873 when they first tried to conquer Aceh. In 1893, Teuku Umar went over to the Dutch side. The Dutch took him into their service and made him commander of a legion of 250 friendly Acehnese soldiers. The Dutch governor regarded him as a trustworthy ally. But Teuku Umar used this opportunity to build up a more powerful position for himself. In 1896, he and his soldiers deserted the Dutch and went back to the Acehnese side. The Dutch pursued him for nearly three years. In January 1899, a force under Governor van Heutsz ambushed and killed him at Meulaboh on the west coast of Aceh.

Teutoburg Forest, Battle of. See **Army** (table: Famous land battles).

Teutonic Knights was the name of an organization of German crusaders that arose in Europe during the 1100's. The Teutonic Knights were organized for service in the Holy Land. They modelled their organization after two earlier crusading orders, the Knights Templars and the Knights Hospitallers (see **Knights Templars; Knights of Saint John**).

In the 1200's, the Teutonic Knights shifted their activities to central Europe, where they tried to convert and control the people of what became Prussia, Lithuania, Latvia, and Estonia. Their power and influence spread throughout central and eastern Europe. In the 1300's, they lost much of their power, and finally the Poles and Lithuanians overthrew them. In 1525, the Grand Master, Albert of Hohenzollern, embraced Protestantism, and changed the Order from a religious to a civil organization. In 1618, the Order's territory passed to the Hohenzollern Elector of Brandenburg.

See also **Latvia** (History); **Lithuania** (History).

Teutons is a name sometimes given to the Germanic peoples. The term comes from the *Teutones,* or *Teutoni,* who, with the Cimbri, were the first Germanic people to threaten ancient Rome's power. With their neighbours, the Ambrones, the Teutones left their homeland around the mouth of the Elbe River in the 100's B.C. In Gaul (now France), they allied themselves with the Cimbri. The Roman general Gaius Marius defeated the Teutones at Aquae Sextiae (now Aix-en-Provence, France) in 102 B.C. He defeated the Cimbri in Italy the following year.

Later, the remnants of the Teutones mixed with other early groups that wandered through Europe. They eventually gave their name to a whole group of *Teutonic,* or *Germanic, languages.* These languages include Dutch, English, German, and the Scandinavian tongues.

Teviot is a river in southern Scotland. It rises on the border between Dumfries and Galloway Region and Borders Region. It flows for nearly 65 kilometres in a northeasterly direction through Borders Region, into the River Tweed at Kelso.

Tewkesbury (pop. 87,400) is a borough and local government district in Gloucestershire, England. The district, which partly encompasses the city of Gloucester, includes the town of Tewkesbury and several charming Cotswold villages. Agricultural products include maize, root crops, fruit, and flowers. Sheep and dairy farming are also important. The town of Tewkesbury stands at the *confluence* (meeting) of the rivers Severn and Avon. It was the scene of a decisive battle in 1471, during the Wars of the Roses. Tewkesbury has a fine abbey with the remains of a Benedictine monastery. See also **Gloucestershire.**

Texas is a state in the Southwestern United States. It is the second largest U.S. state in area, after Alaska. Among the states, only California has more people than Texas. Austin is the capital of Texas, and Houston is the largest city.

Frontier cowboys with their 10-gallon hats have long been a symbol of Texas. Cowboys still ride across the plains tending great herds of cattle. Many Texans still wear cowboy boots and hats. Texas today, however, offers a wide variety of employment. Thousands are employed in the aerospace industry. The headquarters for manned spacecraft projects of the National Aeronautics and Space Administration (NASA) is in Houston.

The land of Texas has helped make the state rich. Many industries benefit from the state's huge agricultural and mining production. Vast plains and rolling hills provide fertile soil and rich grasslands. Texas has more

Central Houston has many modern skyscrapers. Houston is the largest city in Texas and a major industrial centre. Buffalo Bayou winds through Houston's Sabine Park in the foreground.

farms and farmland than any other U.S. state. Texas' large petroleum and natural gas deposits have also brought great wealth to the state.

Many colourful figures are part of Texas history. Texas was a part of Mexico when the first Americans settled there. Davy Crockett, a popular folk hero, was killed at the Alamo, in San Antonio, fighting for independence from Mexico (1836). Afterwards, Sam Houston led the Texans to their final victory with his battle cry "Remember the Alamo!"

Land. Texas has five main land regions. *The Gulf Coastal Plains* are part of the fertile lowland that lies along the Gulf Coast of the United States. A subtropical region extends along a large part of the coast.

In the southern part of the coastal plain, the Rio Grande and Middle Nueces Valleys are noted for their winter vegetables and fruit. Cotton and grain crops thrive along part of the eastern coast. The northeastern part of the plain has forests and mineral deposits.

The Prairie Plains lie west of the forest belt of the Coastal Plains. The Prairie Plains feature alternating belts of rolling hills and forested, rugged hills. The region also includes the fertile Black Waxy Prairie.

The Rolling Plains are a hilly area west of the Prairie Plains. The area's elevation increases as it approaches the plains to the west. The Rolling Plains have scattered belts of farmland and petroleum deposits.

Facts in brief about Texas

Population: *1990 census*—17,059,805.
Area: 691,030 km².
Climate: *Average January temperature*—8° C. *Average July temperature*—28° C.
Elevation: *Highest*—Guadalupe Peak, 2,667 m. *Lowest*—sea level along the Gulf of Mexico.
Largest cities: Houston (1,630,553), Dallas (1,006,877), San Antonio (935,933), El Paso (515,342).
Chief products: *Agriculture*—beef cattle, cotton. *Manufacturing*—chemicals, food products, electrical equipment, petroleum products, machinery, transportation equipment. *Mining*—petroleum, natural gas.
Origin of name: Spanish pronunciation of the Indian word *Tejas* (friends or allies).
Nickname: The Lone Star State. (Because of the single star on its flag.)

The Great Plains reach westward from the Prairie Plains and Rolling Plains into the state of New Mexico. They form part of the series of treeless plains that extends northward through the United States into Canada.

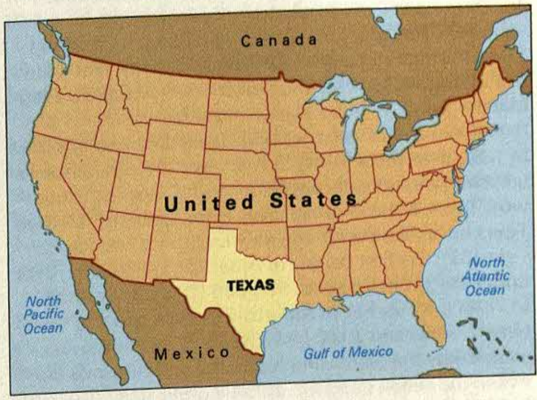
The Texas Panhandle, part of the Great Plains, is the northwestern part of the state that juts northward between Oklahoma and New Mexico. This treeless grassland has rich farmland and rich petroleum and natural gas fields.

The Edwards Plateau forms the southern part of the Great Plains. Its surface is mainly bare limestone bedrock. Sheep and goats graze the thick grasses that grow in the plateau's river valley and basins.

The Basin and Range Region makes up the westernmost part of Texas. It includes high, partly dry plains that are crossed by *spurs* (extensions) of the Rocky Mountains. Farmers use the level sections mainly for raising cattle. Many beautiful mountain gorges are along the upper Rio Grande, which forms the region's western border.

A series of narrow sand bars lies along the Texas coast. Padre Island, the largest sand bar, is about 160 kilometres long. The coast has 28 artificially created ports. They were once filled by *silt* (particles of earth) left by streams emptying into the Gulf of Mexico.

The Rio Grande, Texas' largest river, is one of the



Texas lies in the Southwestern United States. The second largest U.S. state, it has Mexico on its southern border.

longest rivers in North America. In the dry western parts of Texas, many streams have water only after a rainstorm. Texas has thousands of lakes that have been artificially made or enlarged. Most were created for hydroelectric power, irrigation, or water storage.

Economy. Texas is the leading U.S. state in annual value of mineral production. Petroleum and natural gas are the leading mineral products in Texas. The market price of oil and gas has a major effect on the state's overall economy.

The Permian Basin, a vast underground region in west Texas, has one of the world's largest deposits of petroleum and natural gas. Large deposits also lie in the Texas Panhandle, along the Gulf Coast, and in the northeast. A vast network of pipelines transports the oil and gas to processing facilities.

Service industries employ about three-fourths of the workers in Texas. The wholesale and retail trade industry is the largest employer. Some of the country's largest indoor shopping malls are in the Dallas-Fort Worth and Houston areas. Grocery stores and petrol stations also employ many people. The Port of Houston handles much wholesale trade.

Other activities within the service industries include banking, education, health care, and transportation. Many large banking companies are based in Dallas, Houston, and San Antonio. The University of Texas in Austin is one of the largest universities in the United States. The Baylor College of Medicine in Houston is a leading centre of medical research. Several major airlines are based in Texas cities.

Chemicals, processed foods, and electrical and electronic equipment are the leading manufactured products made in Texas. Texas is one of the world's main producers of petrochemicals, which include benzene, ethylene, and propylene. Major parts of the state's food-processing industry include the production of baked goods, beer, packaged meat, and soft drinks.

Texas is a leading agricultural state. Beef cattle provide about half of the state's annual farm income. Texas leads the states in number of beef cattle.

Cotton is Texas' most valuable crop and the second-ranking farm product. Texas produces more cotton than any other state. Texas is also a major producer of grain sorghum, hay, and wheat.

History. When the first Europeans arrived, about 30,000 Indians lived in what is now Texas. Spanish adventurers, for "glory, God, and gold," began exploring Texas during the early 1500's. The Spaniards sent many expeditions to look for the *Seven Cities of Cibola,* a legendary group of cities of great wealth.

Franciscan missionaries built Texas' first two missions in 1682, near present-day El Paso. By 1731, Spain had established missions throughout central, east, and southwest Texas. Mexico broke away from Spain in 1821, and Texas became a part of the new Empire of Mexico.

In 1821, the first colony of Americans settled in Texas under the sponsorship of Stephen F. Austin. From 1821 to 1836, the number of American settlers grew to between 25,000 and 30,000. Mexican officials became alarmed by the increasing numbers, and relations between the settlers and the officials grew steadily worse. In 1834, General Antonio López de Santa Anna, a Mexican politician and soldier, overthrew Mexico's government and made himself dictator. The next year, the American colonists in Texas revolted against Mexico.

Texan troops captured San Antonio on Dec. 11, 1835. Santa Anna assembled a large army and marched on the city. Texan rebels withdrew behind the Alamo, the chapel of an old Spanish mission. The Alamo fell to Santa Anna on March 6, 1836. On April 21, Texas won independence when Sam Houston's troops captured Santa Anna and crushed his army at San Jacinto.

For nearly 10 years after the war, Texas remained an independent republic. It became a U.S. state in 1845. Disputes over the boundary between Texas and Mexico led to the Mexican War (1846-1848). Mexico gave up all claims to southwestern lands after the war.

Texas *seceded* (withdrew) from the U.S.A. and joined the Confederate States of America in March 1861 in spite of strong Union feeling in some sections of the state. After the American Civil War (1861-1865), Northern sympathizers called *Radicals* rose to power in Texas state politics (see **American Civil War**). Racial violence broke out and the Ku Klux Klan became powerful (see **Ku Klux Klan**). Texas was readmitted to the Union on March 30, 1870.

From the mid-1860's to the 1880's, Texans drove cattle along trails to railway centres in Kansas and Missouri. Railways crossed Texas in the 1880's, ending the cattle drives and aiding settlement.

The state's great oil and gas industries began in 1901 with the discovery of the Spindletop oil field near Beaumont. The annual value of manufactured goods more than doubled between 1900 and 1910.

During the early 1920's, Texas Governor Pat M. Neff made important improvements in education and prisons. Great highway construction took place during the 1920's and 1930's. New legislation helped ease hardships during the Depression and droughts of the 1930's.

During World War II (1939-1945), over a million servicemen trained in Texan military camps. After the war, manufacturing expanded rapidly. Texas began to shift from a rural, farm economy to an urban, industrial one.

As in many other U.S. states, civil rights issues associated with racial discrimination arose in the 1950's and 1960's. On Nov. 22, 1963, Lyndon B. Johnson of Texas became President of the United States after the assassination of President John F. Kennedy in Dallas. Texas took a leading role in the U.S. space programme during the 1960's. In 1969, officials at the NASA headquarters near Houston directed the Apollo 11 flight, in which astronauts made the first landing on the moon. During the mid-1980's, the state's economy was deeply hurt by a sharp decline in oil and natural gas prices. By 1990, the economy had begun to recover.

See also **Houston; Dallas; San Antonio; Alamo.**

Texas fever. See **Cattle tick.**

Texas Rangers are special police officers of the U.S. state of Texas. They serve under the authority of the State Department of Public Safety. The Rangers wear no official uniforms. They furnish their own clothing. The state provides weapons and transportation. But Rangers may carry their own weapons, and they ride their own horses. The Rangers originated in the early 1800's, as a band of mounted riflemen, formed to protect American settlers along the Brazos River from Indian warriors and Mexican bandits.

A wide variety of textile products—from carpeting, clothing, and towels to fire hoses, typewriter ribbons, and umbrellas—helps meet the needs of people throughout the world.

Textile

Textile has traditionally meant a woven fabric. The term comes from the Latin word *texere,* meaning *to weave.* Many fabrics are still made by weaving yarn on a loom. But today, all other types of fabrics are also considered textiles. They include knitted goods, felts, laces, nets, and braids. The textile industry also refers to the fibres and yarns which are used to manufacture fabrics as textiles.

Textile mills produce an incredible variety of fabrics. They turn out huge rolls of soft cotton, warm wool, strong nylon, and other fabrics. The mills produce these textiles in every colour imaginable and in countless patterns. The largest share of all textile production goes to garment manufacturers to be made into ready-to-wear clothing. The second-largest share is used to make such household products as curtains, blankets, sheets, and towels.

Textiles are also used in thousands of other products. These products include basketball nets, boat sails, bookbindings, conveyor belts, fire hoses, flags, insulation materials, mailbags, parachutes, typewriter ribbons, and umbrellas. Car manufacturers use fabrics in the carpeting, upholstery, tyres, and brake linings of cars. Hospitals use such textile products as adhesive tape, bandages, and surgical thread. Surgeons replace diseased heart arteries with arteries knitted or woven from textile fibres.

Most textiles are produced by twisting fibres into yarns and then knitting or weaving the yarns into a fabric. This method of making cloth has been used for thousands of years. But throughout most of that time, workers did the twisting, knitting, or weaving largely by hand. With today's modern machinery, textile mills can manufacture as much fabric in a few seconds as it once took workers weeks to produce by hand.

Sources of textile fibres

Fibres are the raw materials for all fabrics. Some fibres occur in nature as fine strands that can be twisted into yarns. These *natural fibres* come from plants, animals, and minerals. Most natural fibres used for textile production measure between about 1 and 20 centimetres. Such short fibres are called *staple fibres.*

For most of history, people had only natural fibres to use in making cloth. But modern science has learned how to produce fibres by chemical and technical means. Today, these manufactured fibres account for more than half the fibres processed in many countries. Unlike most natural fibres, manufactured fibres are produced in long, continuous lengths called *filaments.* Many manufactured fibres also have certain qualities superior to those of natural fibres. For example, they may be stronger or more elastic.

Natural fibres. Plants provide more textile fibres than do animals or minerals. In fact, one plant, cotton, accounts for more than 90 per cent of the natural fibres used in some countries. Cotton fibres produce soft, absorbent fabrics that are widely used for clothing, sheets, and towels. Fibres of the flax plant are made into linen. The strength and beauty of linen have made it a popular

Manufactured fibres

Fibre	Characteristics	Uses
Acetate	Resists mildew, shrinking, stains, and stretching	Clothing; curtains; upholstery
Acrylic	Soft; resists mildew, sunlight, and wrinkling	Blankets; carpeting; clothing; upholstery
Aramid	Resists heat, chemicals, and stretching	Bulletproof vests; electrical insulation; rope; tyres
Glass	Resists chemicals, flames, mildew, moisture, and sunlight	Curtains; electrical insulation; ironing board covers
Metallic	Resists insects, mildew, and tarnishing	Decorative trim for bedspreads, tablecloths, and upholstery
Modacrylic	Soft; resists chemicals, flames, and wrinkling	Artificial furs; blankets; carpeting; wigs
Nylon	Strong; elastic; easy to launder; dries quickly; retains shape	Carpeting; hosiery; lingerie; parachutes; upholstery
Olefin	Lightweight; resists insects, mildew, moisture, and sunlight	Car seat covers; filters; indoor-outdoor carpeting
Polyester	Resists wrinkling; easy to launder; dries quickly	Blankets; carpeting; clothing; fire hose; sewing thread
Rayon	Absorbent; easy to launder; dyes easily	Carpeting; clothing; curtains; upholstery
Rubber (synthetic)	Strong; elastic; repels moisture	Mattresses; support hose; swimwear; underwear
Saran	Resists acids, insects, mildew, moisture, and stains	Curtains; outdoor furniture; rainwear; upholstery
Spandex	Elastic; lightweight; resists sunlight and perspiration	Fitted sheets; slipcovers; support hose; swimwear; underwear

fabric for fine tablecloths, napkins, and handkerchiefs. Fibres of the jute plant can be woven into burlap. Burlap is used for sacks and as backing for certain types of rugs and carpets.

The main animal fibre used for textiles is wool. Another animal fibre, silk, produces one of the most luxurious fabrics. Sheep supply most of the wool, but members of the camel family and some goats also furnish wool. Wool provides warm, comfortable fabrics for dresses, suits, and sweaters. Silk comes from cocoons spun by silkworms. Workers unwind the cocoons to obtain long, natural filaments. Fabrics made from silk fibres have great lustre and softness and can be dyed brilliant colours. Silk is especially popular for fashionable clothing, scarfs, and ties.

The only natural mineral fibre used for textiles is asbestos, which comes from rocks. It will not burn, but it melts at very high temperatures. Manufacturers use it in making brake linings and other products. Inhalation of asbestos fibres can cause *asbestosis* (an inflammation of the lungs). As a consequence, several countries have banned the use of asbestos in the manufacture of certain fibre products.

Manufactured fibres. Most manufactured fibres are made from *wood pulp,* cotton *linters,* or *petrochemicals.* Wood pulp comes from trees and the waste products of the timber industry. Linters are the short fibres remaining on the cottonseeds after the longer fibres have been removed by the cotton gin. Petrochemicals are chemicals made from crude oil and natural gas.

The fibres made from wood pulp and linters are rayon and acetate. These fibres are called *cellulosics* because they are made from the cellulose in wood pulp and cotton. Rayon and acetate are widely used for clothing, curtains, and upholstery. The properties of rayon resemble those of cotton. Rayon produces absorbent fabrics that dye easily. Fabrics of acetate are silkier than rayon. Acetate resists shrinking and stretching.

The chief fibres manufactured from petrochemicals include nylon, polyester, acrylic, and olefin. Nylon has great strength, wears well, and is easy to launder. It is popular for hosiery and other clothing and for carpeting and upholstery. Such products as conveyor belts and fire hoses are also made of nylon. Polyester resists wrinkling and is widely used in permanent press clothing. Acrylic makes a soft, bulky, lightweight fabric for blankets, carpeting, and the outer covering of insulated jackets. Olefin cleans easily, dries quickly, and resists mildew. It is used for indoor-outdoor carpeting.

Other manufactured fibres include those made from glass and metals. Fabrics of glass fibres are used for insulation and to make boat hulls, moulded products, and flame-resistant fabrics. Metallic fibres are made chiefly by bonding aluminium, gold, and silver foils to plastics. These fibres provide decorative yarns for bedspreads, evening gowns, and tablecloths.

Kinds of fabrics

The majority of fabrics produced in most countries are made by weaving or knitting. The rest are made by other processes. In producing fabrics by the various processes, textile mills may use yarns finer than sewing thread or as heavy as rug yarn.

Woven fabrics are made of two sets of yarns—a lengthwise set called the *warp* and a crosswise set called the *filling* or *weft.* The warp yarns are threaded into a loom through a series of frames called *harnesses.* During the cloth-making process, the harnesses raise some warp yarns and lower others. This action creates a space, or *shed,* between the yarns. A device called a *shuttle* carries the filling through the shed and so forms the crosswise yarns of the fabric. The pattern in which the harnesses are raised and lowered for each pass of the shuttle determines the kind of weave. There are three basic patterns: (1) the plain weave, (2) the twill weave, and (3) the satin weave.

The plain weave is the simplest and most common pattern. In this weave, the crosswise filling passes over one warp yarn and under the next alternately across the width of the fabric. The weave produces long-lasting, flat-textured cloth used in making such products as bedsheets, dresses, and upholstery. Plain-woven fabrics include gingham, percale, and taffeta.

The twill weave has a pattern of raised diagonal lines. The filling crosses over and then under two, three, or four warp yarns at a time, with each row following the same pattern. However, each row's pattern begins slightly to the right or left of the pattern in the previous row. This technique creates the diagonal lines. The twill weave produces strong, tightly woven cloth used in coats, sportswear, and work clothes. Popular twill fabrics include denim and gabardine.

The satin weave is the least common pattern. The filling may span as many as 12 warp yarns. The weave produces soft, luxurious cloth, but it may snag easily. Satin-weave fabrics are made into such products as curtains and formal clothes. Common satin weaves include damask and satin.

Knitted fabrics are made from a single yarn or a set of yarns. In making cloth, a knitting machine forms loops in the yarn and links them to one another by means of needles. The finished fabric consists of crosswise rows of loops, called *courses,* and lengthwise rows of loops, called *wales.* This looped structure makes knitted fabrics more elastic than woven cloth. Garment manufacturers use knitted fabrics in producing comfortable, lightweight clothing that resists wrinkling. Textile mills manufacture knit goods by two basic methods: (1) weft knitting and (2) warp knitting.

Weft knitting is done with single lengths of yarn, which a knitting machine forms into the crosswise courses one row at a time. The loops of each course are pulled through the loops of the previous course. This process forms the wales at the same time as the courses. Weft knits can be made in the shape of a tube or as flat pieces of cloth.

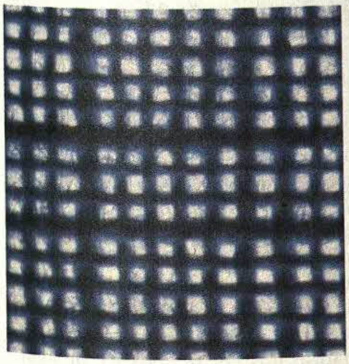
Most weft-knitted fabrics are used in making hosiery, sweaters, and underwear. These fabrics are knitted in three basic stitches. In the *plain,* or *jersey, stitch,* the tops of the loops stand out on the face of the cloth, and the bottoms of the loops stand out on the back. The *purl stitch* produces crosswise ridges on both sides of the fabric. The *rib stitch* makes cloth with lengthwise ribs on the front and back. Another stitch, the *double knit,* produces a heavier, more tightly constructed fabric than do the other stitches. Double-knit dresses, men's suits, and sportswear are highly popular because of their wrinkle resistance.

Warp knitting requires hundreds of yarns fed as a sheet to a knitting machine. A separate needle for each yarn forms the wales of the fabric. At the same time, the needles interloop the wales crosswise and so form the yarns into a fabric. Almost all warp knits are produced in flat pieces.

Warp-knitted fabrics are tightly constructed and thus do not stretch as much as weft knits. In warp knits, the loops stand out on the face of the cloth, and the connecting yarns stand out on the back. Common warp-knitted fabrics include tricot and raschel. Tricot knits are lightweight fabrics that are widely used in making bedsheets, blouses, dresses, and women's underwear. Raschel knits are heavier fabrics and are used for a variety of products, including blankets, carpeting, men's suits, and swimwear.

Other fabrics include tufted fabrics, nets and laces, braids, and felt. None of these fabrics is woven. However, the textile industry produces another class of fabrics specifically called nonwoven fabrics.

Tufted fabrics are used in a large proportion of the carpeting produced in many industrial countries. Such



A woven fabric consists of two sets of yarns. The yarns are crossed over and under each other to form cloth.

A knitted fabric has a single yarn or a set of yarns. Loops are made in the yarn and linked together, forming cloth.

Felt is made chiefly from fibres of wool, fur, or animal hair. The fibres are matted together by moist heat and pressure.

fabrics consist of cut or uncut loops of yarn that have been punched through a backing material.

Nets and laces, which are called *open-mesh fabrics,* have wide spaces between the yarns. These fabrics can be produced on certain kinds of knitting machines. Netting is used for curtains, fishing nets, hammocks, and tennis nets. Laces have delicate designs and are popular as trim for clothing.

Braids consist of three or more interlaced yarns. Braided fabrics are used for such narrow items as ribbons and shoelaces.

Felt is chiefly produced from fibres of wool, fur, or animal hair. The fibres are matted together by moist heat and pressure. Felt is used in making billiard table covers, hats, and padding.

Nonwoven fabrics include *needle-punched fabrics* and fabrics produced by a process called *bonding.* Needle-punched fabrics, or *needle felts,* consist of fibres that have been tangled together by means of hooked needles. Such fabrics look like felt and are used in making blankets, indoor-outdoor carpeting, and insulation. Fabrics produced by bonding are made by joining fibres with adhesives. Many of these fabrics are made into items that are used only once, such as disposable nappies and surgical gowns.

How fabrics are produced

Designing a fabric. Most fabric designers work for companies that manufacture fibres, fabrics, or clothing. Designers create new patterns and colour combinations and decide what fibres and methods of construction to use in various fabrics. They must know enough about textile production to realize whether their ideas can be converted into actual products. Fabrics must also be designed so that they can be produced economically on standard textile machinery, such as looms, knitting machines, and tufting machines. In addition, a design has to appeal to a great many consumers for the fabric to be profitable.

Making the yarn. Yarn can be manufactured in various ways. Fibre companies may take filaments—that is, long, continuous fibres—and draw 15 to 100 of them together to make *multifilament* yarn. Or they may use a single filament to make *monofilament* yarn. Some filament yarns, including those made from nylon and polyester, can be *heat-set* to form *stretch yarns.* In one method of heat-setting, manufacturers tightly twist the yarn and heat it. After the yarn is untwisted, it tends to snap back like a spring. Such yarn is used in double-knit and stretch-woven fabrics. Other treatments can be applied to filament yarns to give them a bulky texture.

Filaments may also be cut into staple, or short, lengths that measure from about 2.5 to 7.5 centimetres long. Staple fibres cut from filaments produce yarn that is softer than filament yarn and not as lustrous. Yarn producers can also mix together natural fibres and manufactured fibres of staple length to form *blended yarns.* These yarns have the characteristics of each of the fibres used in their construction. For example, yarn produced from cotton and polyester is absorbent because it contains cotton and wrinkle resistant because it contains polyester.

Yarn made from natural fibres or manufactured fibres of staple length is called *staple yarn* or *spun yarn.* All staple yarns are manufactured in much the same way, whether they are blended or consist of only one kind of fibre. The fibres arrive at the mill in bales, which workers feed into a series of *opening machines.* These machines break up the large masses of fibres, remove some of the impurities, and mix the fibres together. A *carding machine* then removes smaller impurities and some of the exceptionally short fibres and arranges the remaining fibres into a loose rope called a *sliver.* Next, as many as eight slivers at a time are drawn together into another sliver. This sliver is then formed into a thin strand called a *roving.* The roving is twisted on a *spinning frame* to form yarn. Some spinning frames produce yarn directly from slivers. Different kinds of fibres may be blended when the bales are opened, when the slivers are drawn together, or when the roving is spun.

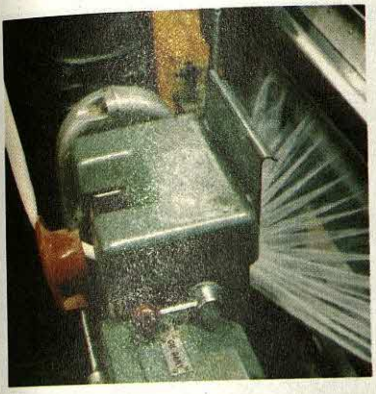
Designing a fabric requires not only artistic ability but also knowledge of fibres and textile machinery. Designers must know whether their ideas can be converted into actual products.

After the yarn has been manufactured, it is wound onto large spools. Sometimes, two or more strands of yarn are twisted together for added strength. Each strand of such heavier yarn is referred to as a *ply.* Three-ply yarn, for example, consists of three strands of yarn. After the yarn has been spooled, it is ready to be woven or knitted.

Making the fabric begins when workers place the spools of yarn on a rack called a *creel.* The creel feeds the yarns onto a *beam* (roller) that is placed on a loom or a knitting machine. For a discussion of how looms and knitting machines make cloth, see the previous section, *Kinds of fabrics.*

Manufacturers produce woven and knitted fabrics in various lengths, depending on the orders of their customers. Woven fabrics made for clothing manufacturers are usually produced in widths of between about 90 and 152 centimetres. Most woven *narrow goods,* which are used for such products as gauze bandages and labels, measure between about 1 and 7.5 centimetres wide.

In general, a knitting mill specializes in one of four kinds of products—fabric; hosiery; underwear; or such outerwear as dresses, shirts, sweaters, and trousers. Most fabric produced in widths of between 200 and 425 centimetres is sold to clothing manufacturers. Fabrics



Making yarn involves processing fibres through various machines. A carding machine, *above,* arranges the fibres into a loose rope called a *sliver.* The slivers are coiled into cans and fed into a spinning frame, *right,* which twists them into yarn.

made in the shape of tubes are used for the bodies of sports shirts and of T-shirts. Such cloth can also be cut and sewed together like flat-knitted fabrics to make garments.

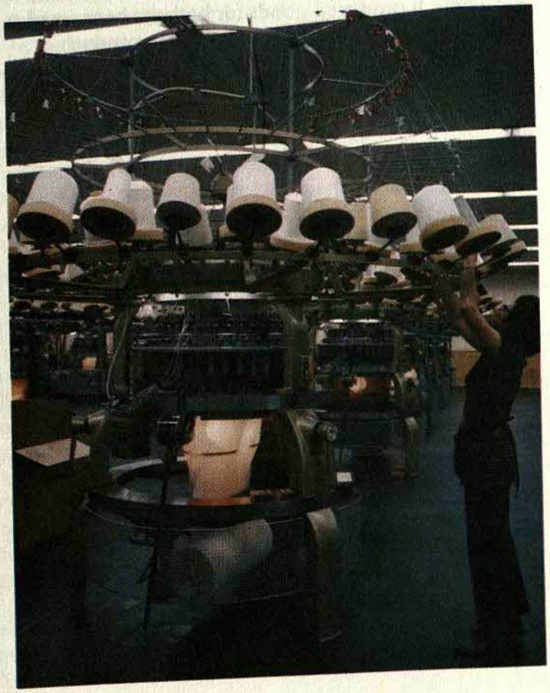
Finishing the fabric. Fabrics that come directly from a loom or knitting machine are called *grey goods.* This term does not refer to the colour of the cloth. It merely means that the fabric has not received any finishing treatments and so is unsuitable for most purposes. Grey goods are also called *greige* (pronounced *grey*).

Almost all grey goods are washed to remove dirt, grease, and other unwanted substances. Many fabrics are also bleached to whiten them or to prepare them for dyeing or printing. Cotton fabrics may be treated with caustic soda before dyeing. This process, called *mercerizing,* swells the cotton fibres and thus increases the strength and lustre of the cloth.

Some grey goods are made from dyed yarn. Such cloth may have brilliant colours and highly detailed designs. But most textiles are dyed a single colour after the yarn has been made into cloth. Dyeing machines pull the fabric through a dyebath or force the dye into the cloth by means of pressure.

Designs are printed on fabrics by three chief methods. *Roller printing* uses rollers that have designs deeply engraved on their surface. Dye is applied to the raised areas and then transferred onto the cloth by the rollers. *Screen printing* is similar to using a stencil to

Weaving on a Jacquard loom, *above,* produces fabric with complex patterns for such items as towels and upholstery. Punched cards and other attachments guide the yarn.



Knitting on a circular knitting machine, *right,* produces fabric for hosiery, underwear, and many other garments. A device at the bottom of the machine rolls up the fabric as it is knitted.

form a design. Dye is pressed onto the cloth through a pattern on a screen. *Rotary screen printing* uses porous rollers that fit inside cylindrical screens. The rollers hold the dye and force it into the cloth through patterns on the screens. In another process, called *heat transfer printing* the design is printed on paper with special ink and then ironed onto the fabric. When the paper is peeled off, it leaves the design on the cloth. Some fabrics are dyed and then printed.

After the cloth has been dyed or printed, it may be dried and stretched on a machine called a *tenter frame.* Fabrics made from heat-set fibres may also be treated by this device to help the cloth resist shrinking and wrinkling. A patented process called *Sanforizing* preshrinks cloth to prevent it from shrinking or stretching more than 1 per cent in home laundering. Other finishing treatments help fabrics resist bacteria, fading, flames, mildew, moths, stains, static, and water.

The final step in manufacturing cloth is ironing it between heavy rollers, a process called *calendering.* The fabrics are then rolled onto bolts for shipment to clothing makers and other customers.

The textile industry

In Asia, millions of workers weave fabrics of cotton and other natural fibres in their homes. Textiles play an important part in the industrialization of developing nations. Textile production provides many jobs that can be filled by unskilled and semiskilled workers. The manufacture of clothing is a major industry in Asia. Countries such as India and the Philippines export textile products, including clothing, to Europe and North America. In Japan, which has a highly advanced industrial economy, textile production is modern and centred on manufactured fibres.

In India and Pakistan, a factory-based textile industry, principally cotton and jute, developed in the early and mid 1900's. It produced goods for both the home market and for export. Two leading cotton textile-producing areas were Ahmadabad in Gujarat and the Coimbatore area of Madras. Today almost all Indian states have some textile manufacturing. The main centres of production are Bombay, Gujarat, Tamil Nadu, and West Bengal. Cotton textiles are a major Indian export, though modernization of cotton mills has been slow. The domestic industry, in which workers spin and weave in their own homes, remains important. Some 400,000 workers in India make *khadi,* or hand-woven cloth.

In Pakistan, natural gas provided the energy for a Karachi-based textile industry in the 1950's. The spinning and weaving industries have grown rapidly in industrial centres like Karachi and Hyderabad. By the 1980's cotton textiles had become a major industry.

In Bangladesh, the most important textile industry is jute milling. Almost all jute goods go for export. Bangladesh also has some cotton mills.

In Australia, the textile industry developed in the mid 1800's. Woollen manufacturing developed in several Australian states, but most textiles were imported from Britain until the 1900's. The government of Australia has protected the textiles and clothing industry against cheap imports, but by the 1980's there were far fewer workers employed in these industries. Many small companies were merged into larger firms.

Dyeing processes may be used either to colour fibres and yarns before they are made into cloth or to colour the fabric itself. In *package dyeing, above,* tubes of yarn are dyed in vats.

Printing produces fabrics with beautiful designs and a variety of colours. In *rotary screen printing, above,* the dye is forced through patterns on cylindrical screens that fit around rollers.

Weaving with a hand loom is still a major way of making cloth in many developing countries. This woman in Guatemala weaves a colourful fabric by an age-old method.

In Europe, textile production is highly mechanized. Germany, Italy, and Switzerland are leading exporters of textile machinery and manufactured fibres. In the United Kingdom, the textile industry includes yarn, woven and knitted fabrics, clothing, household textiles, and carpets. The industry is concentrated in the English Midlands, especially around Leicester and Nottingham. Lancashire was once the centre of the cotton industry, but the industry there has declined. The linen industry is centred in Northern Ireland. Heavyweight materials (for tents and sailcloth) are made in Scotland. Thick tweed cloth is made in southern Scotland, near the River Tweed. Jute products are manufactured around Dundee in Scotland. West Yorkshire in England is famous for woollens and worsteds. Most natural raw materials, such as cotton and wool, are imported. British mills also process much of the world's trade in luxury fibres such as mohair and cashmere.

In most of the countries of Eastern Europe, textile production is also highly mechanized, but is less modern than in Western Europe. Natural fibres have greater importance in these countries than in most Western European nations.

In North America, the United States has more than 5,500 textile companies operating more than 7,000 plants. Many of these companies perform every step in the manufacturing process, from making the yarn to finishing the fabric. But some manufacturers specialize in only one operation. For example, a textile mill may produce cloth with yarn it buys from one company and then sell the fabric to another firm for finishing. In Canada there are about 1,200 textile mills.

The governments of many countries require the textile industry to observe certain laws designed to protect consumers and to give them information about the textiles they buy. Such laws may require all textiles to carry a label telling the amount and kind of fibres used. Garment manufacturers may be required to label clothing with cleaning, ironing, and bleaching instructions.

History

Prehistoric and ancient times. No one knows when people first made textiles. The earliest evidence of woollen textiles dates from about 6000 B.C. This evidence comes from what is now southern Turkey. Bits of linen from Egypt indicate that people there wove flax about 5000 B.C. Archaeologists have found Egyptian mummies from the 2500's B.C. wrapped in linen as well made as that produced today. By 3000 B.C., cotton was grown in the Indus River Valley in what are now Pakistan and western India. Cotton may also have been used for textiles in the Americas by this time. The Chinese began to cultivate silkworms about 2700 B.C. They developed special looms for silk filaments.

The ancient Greeks used chiefly woollen textiles. They also used some linen. In the 300's B.C., Alexander the Great's army brought cotton goods from what is now Pakistan to Europe. The ancient Romans developed an enormous trade in textiles. They imported woollens from Britain, Gaul (now France), and Spain; linen from Egypt; cottons from India; and silks from China and Persia (now Iran).

During the Middle Ages, from the A.D. 400's to the early 1500's, the textile industry gradually developed in Europe. The production of woollens centred in England, northern Italy, and Flanders (a region that now covers parts of present-day Belgium, France, and the Netherlands). As the textile industry expanded, production techniques improved, stimulating further growth. The spinning wheel had come into use by the 1200's. Meanwhile, Italy had become the silk centre of Europe. The invention of a machine to unwind silk from cocoons led to further expansion of Italy's silk industry.

In the large towns of Europe, associations of weavers and other craftworkers regulated textile production. These associations, called *guilds,* established prices and standards of quality for all products made by their members. But the *cottage industry,* also called the *domestic system,* produced most textiles during the Middle Ages. Under this system, merchants delivered raw materials to workers in their homes in rural areas. Later, the merchants collected the work and paid the workers for it by the piece.

The Industrial Revolution. Important developments in textile production continued after the Middle Ages. For example, an English clergyman named William Lee invented a machine for knitting hosiery in 1589. During the 1600's, textile workers in the Netherlands developed improved methods of dyeing and finishing cloth. But the greatest advances in the textile industry occurred during the Industrial Revolution, which began in England in the 1700's. In fact, the Industrial Revolution was largely a "textile revolution" created by a flood of English inventions that enormously increased the production of yarns and fabrics.

In 1733, John Kay, an engineer, invented the *flying shuttle.* This device enabled weavers to pass the filling through the warp yarns mechanically instead of by hand. About 1764, a weaver named James Hargreaves invented the *spinning jenny,* the first machine that could spin more than one yarn at a time. In 1769, Richard Arkwright, a former barber, patented the *water frame,* a spinning machine that ran on water power. A weaver named Samuel Crompton introduced the *spinning mule* in 1779. This machine combined the features of the spinning jenny and the water frame and gradually replaced them both. Edmund Cartwright, an Anglican clergyman, patented the first power loom in 1785.

In 1793, the American inventor Eli Whitney developed his cotton gin. Before Whitney's invention, workers had to remove cotton fibres from the seed by hand. This slow process could not meet the textile mills' demand for cotton. Whitney's cotton gin separated the fibres far faster than workers could by hand. As a result, textile mills received ever-increasing supplies of cotton.

The age of modern textiles began in 1884, when Hilaire Chardonnet, a French chemist, developed the first practical manufactured fibre. This fibre, now known as rayon, was first produced in the United States in 1910 under the name *artificial silk.* Wallace H. Carothers, an American chemist, developed nylon in the mid-1930's. During the 1940's and 1950's, polyester, acrylic, and other manufactured fibres were introduced.

In the 1960's, textile companies began making double-knit fabrics of textured polyester yarns. These fabrics were lighter in weight and more comfortable than double knits made of other materials. As a result, the popularity of knits greatly increased.

Today, new manufacturing processes and devices have made the textile industry one of the most modern of all industries. For example, knitting machines controlled by computers now produce fabrics with highly complex patterns at tremendous speeds. Many textile firms also use high-speed looms that have many tiny shuttles called *darts* instead of a single shuttle. Other looms weave with no shuttles at all. A jet of water or air carries the filling through the warp up to 1,000 times a minute, about four times faster than a shuttle works on a standard loom.

Related articles in ***World Book*** include:

Biographies

Arkwright, Sir Richard
Cartwright, Edmund
Chardonnet, Hilaire
Crompton, Samuel
Hargreaves, James
Jacquard, Joseph Marie
Kay, John
Slater, Samuel

Textiles

See the articles on clothing materials that are listed in the *Related articles* section of the **Clothing** article. See also the following articles:

Braiding
Burlap
Cambric
Fibre
Flax
Oilcloth
Tapestry
Twill

Treatments and processes

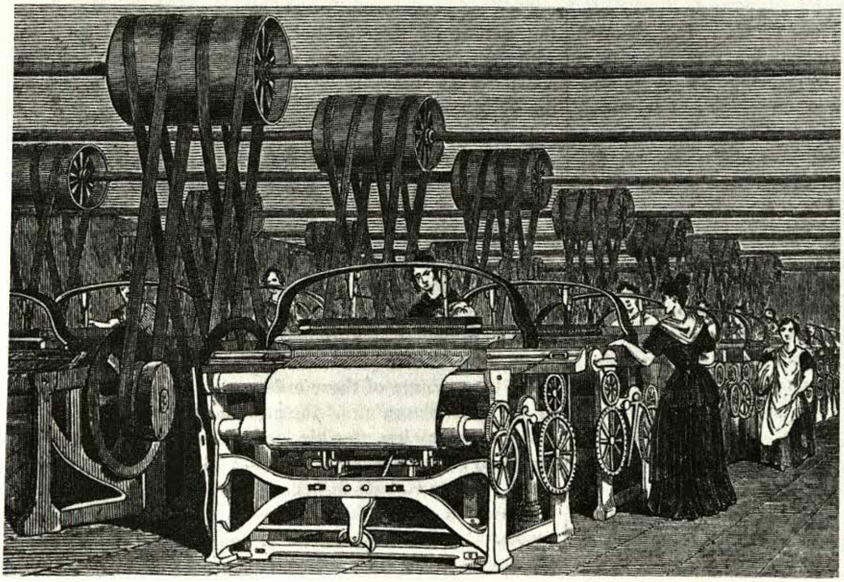
Batik
Bleach
Dye
Embroidery
Knitting
Knitting machine
Spinning
Spinning jenny
Tie dyeing
Waterproofing
Weaving

Other related articles

Brown lung
Clothing
Cottage industry
Guilds
Industrial Revolution
Rugs and carpets

Outline

I. Sources of textile fibres
  A. Natural fibres
  B. Manufactured fibres
II. Kinds of fabrics
  A. Woven fabrics
  B. Knitted fabrics
  C. Other fabrics
III. How fabrics are produced
  A. Designing a fabric
  B. Making the yarn
  C. Making the fabric
  D. Finishing the fabric
IV. The textile industry
  A. In Asia
  B. In Australia
  C. In Europe
  D. In North America
V. History



New textile machinery of the 1800's greatly increased fabric production. In textile mills like the one on the left, women operated looms powered by steam engines or water wheels.

Questions

What two methods of making cloth account for the majority of fabrics produced in most countries?
What was the first practical manufactured fibre?
Which industry consumes the largest share of all textile production?
What was the *domestic system*?
How are most carpeting fabrics made in many industrial countries?
What are *grey goods*?
What is the most important natural fibre?
From what substances are most manufactured fibres produced?
How must clothing be labelled in many countries?
What is *blended yarn*? *Staple yarn*?

Textile engineering. See **Engineering** (Other specialized fields).

Texture. See **Interior decoration** (Pattern and texture; Choosing patterns and textures).

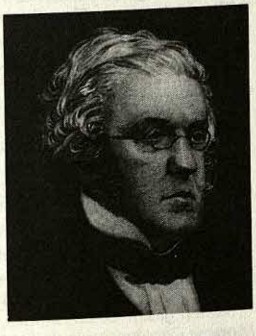
Teyte, Dame Maggie (1888-1976), achieved fame as an opera and concert singer. Her soprano voice was fresh and clear and beautifully controlled. Her interpretation of the works of Mozart and Debussy was particularly outstanding. Debussy chose her to sing the role of Mélisande in his opera *Pelléas et Mélisande.* Maggie Teyte was born in Wolverhampton, England. She studied in London and Paris.

Dame Maggie Teyte

Tezel, Johann. See **Tetzel, Johann.**

Thackeray, William Makepeace (1811-1863), was one of the great novelists of the English Victorian Age. His *Vanity Fair* is one of the finest and best-known novels in English literature. Thackeray wrote in a colourful, lively style, with a simple vocabulary and clearly structured sentences. These qualities, combined with his honest view of life, give him an important place in the history of realistic literature.

Early career. Thackeray was born in Calcutta, India. In 1817, he was sent to England to live with relatives and begin his education. He later looked back on his school years with mingled affection and dislike. Said Thackeray, "I have the same recollection of Greek in youth that I have of castor oil." He entered Trinity College, Cambridge University, in 1829. No great scholar, he left after a year and a half to travel abroad.



William Thackeray

Thackeray had trouble finding a career. He studied law for a short time, and went to art school in Paris. Meanwhile, he had spent his inheritance, losing part of it to professional gamblers. To make a modest living, he turned to writing book reviews, stories, and satirical sketches for magazines.

In 1836, Thackeray married Isabella Shawe. She became mentally ill following the birth of their third daughter in 1840. This tragedy affected Thackeray's natural good humour, making him lonely and depressed. But he needed money more than ever, and he continued to write and sell his articles and stories.

Most of Thackeray's early writings were humorous, and were published under such ridiculous pen names as Michael Angelo Titmarsh. In 1848, he published *The Book of Snobs,* a collected edition of his magazine writings.

Later career. Thackeray ensured his fame with *Vanity Fair* (1847-1848), probably his best novel. Like most of his books, it was first published in monthly parts. The novel traces the fortunes of upper-middle-class Londoners of the early 1800's.

Thackeray called *Vanity Fair* "a novel without a hero," in keeping with his belief that most people are a mixture of the heroic and the ridiculous. He knew that men and women are complex, and he avoided oversimplifying them. He wrote with affection about kind and gentle Amelia Sedley. But he also called Amelia "a silly little thing." Becky Sharp, more clearly the "heroine," is selfish, cunning, and cynical. Becky is never bitter, however, and readers enjoy seeing her good-naturedly defeat people who are even less admirable than she.

The novel *Pendennis* (1848-1850) is partly autobiographical. It has the mellow, reflective quality that colours much of Thackeray's writing.

Henry Esmond (1852) is set in England in the early 1700's, a period that Thackeray loved. The book describes the loves and adventures of Esmond, who narrates the book. Henry is also only "part hero." Although well meaning, he is given to pious moralizing, which sometimes makes him a most unheroic bore.

The Newcomes (1853-1855) is the complex story of three generations of the Newcome family. Ethel Newcome is one of Thackeray's finest characters. She has gentleness and sympathy, but also intelligence and spirit. Thackeray's later novels show the diminished energy of an author who was ill and tired.

Thackeray's view of life. Thackeray disliked people who were unduly impressed by birth and rank. His skilful ridicule of snobs and hypocrites is even evident amid the broad humour of his early works. His realistic temperament enabled him to see and satirize inconsistencies in life. He once said of one of his characters that he "failed somehow in spite of a mediocrity which ought to have ensured any man a success." Thackeray knew that rogues sometimes do well while it is often the innocent who suffer, and that virtuous people can be dull and rascals lively. Such ironic twists in his books were misunderstood by some people, who accused him of being cynical.

Others complained that Thackeray's writings were sentimental. For example, he seemed to admire womanhood as an abstract ideal. When he wrote about young ladies who were gentle and affectionate but perhaps not very bright, he sometimes fell into a style of adoration. But his deep honesty made him show, at the same time, how these sentimental people were often stupid and dull. His critics often fail to see that Thackeray really hated cruelty and greed, and admired goodness and warm-heartedness.

Robert Frerck, Odyssey Productions

Bangkok, a booming metropolis on the Chao Praya River, is Thailand's capital and largest city. Its landmarks include the ornate towers of the Grand Palace, *above.*

Thailand

Thailand is a tropical country in Southeast Asia. The people of Thailand are called Thai. Most are farmers and live in small, rural villages. However, Thailand has one of the fastest growing economies in the world, and its urban centres have expanded rapidly. Almost 6 million people live in Bangkok, Thailand's capital and largest city.

Thailand is the only nation in Southeast Asia that has never been ruled by a Western power. The Thai people date their history from A.D. 1238, when the Sukhothai Kingdom was founded in what is now Thailand. For most of its history, the country was called Siam. In 1939, it officially adopted the name Thailand.

Government

National government. Thailand is a constitutional monarchy, a form of government in which the constitution limits the power of the king or queen. The nation's Constitution provides for a monarch, a prime minister, and a legislature called the National Assembly. The monarch has an advisory role as head of state, and the prime minister heads the government.

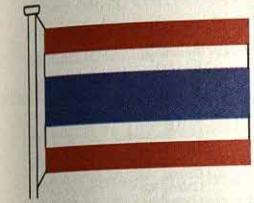
The National Assembly consists of the House of Representatives with 360 members and the Senate with 270 members. The House members are elected by the people of Thailand and serve four-year terms. The senators are chosen by the ruling parties in the House and are formally appointed by the monarch. Senators serve six-year terms. The National Assembly selects the prime minister, who is then formally appointed by the monarch. The prime minister selects the Cabinet, which has a maximum of 48 members.

Local government. Thailand is divided into more than 70 provinces. The provinces are subdivided into more than 600 districts, about 6,600 units of local government called *tambons,* and about 60,000 villages. Each province has a governor, and every district has a district officer. These officials are appointed by the minister of the interior. Thai villages range in size from a few hundred to a few thousand people. Each village elects a *headman* to be its leader. The people within each tambon then select from among the village headmen a *kamnan,* or chief administrator, for their tambon.

Politics. Thai citizens 20 years old or older have the right to vote. Thai political parties, however, have most

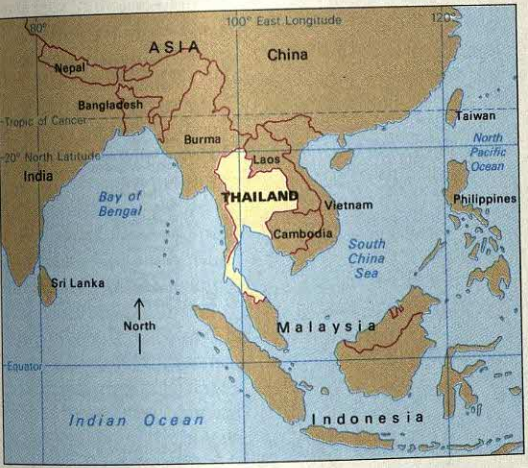
Facts in brief

Capital: Bangkok.
Official language: Thai (Central dialect).
Official name: Pratet Thai.
Area: 513,115 km². *Greatest distances*—north-south, 1,770 km; east-west, 772 km. *Coastline*— 2,615 km.
Elevation: *Highest*—Inthanon Mountain, 2,595 m. *Lowest*—sea level.
Population: *Estimated 1996 population*—58,836,000; density, 114 people per km²; distribution, 75 per cent rural, 25 per cent urban. *1990 census*—54,532,300. *Estimated 2001 population*—61,765,000.
Chief products: *Agriculture*—cassava, maize, pineapples, rice, rubber, sugar cane. *Manufacturing*—cars, cement, electronic goods, food products, plastics, textiles. *Fishing*—herring, tuna, shrimp and other shellfish. *Mining*—copper, iron ore, lead, natural gas, precious stones, tin, zinc.
Money: *Currency unit*—baht. One baht = 100 satang.



Thailand's flag was adopted in 1917. The red represents the nation; the white, purity; and the blue, the monarchy.

The national emblem, adopted in 1910, shows the *garuda,* a birdlike creature of Southeast Asian mythology.



Thailand is a country that lies mostly in mainland Southeast Asia. Southern Thailand extends down the Malay Peninsula.

often come to power through a military *coup* (revolt against the ruling party) rather than through popular elections. Traditionally, Thai political parties have been organized around leaders rather than common political philosophies, and few parties have had lasting strength.

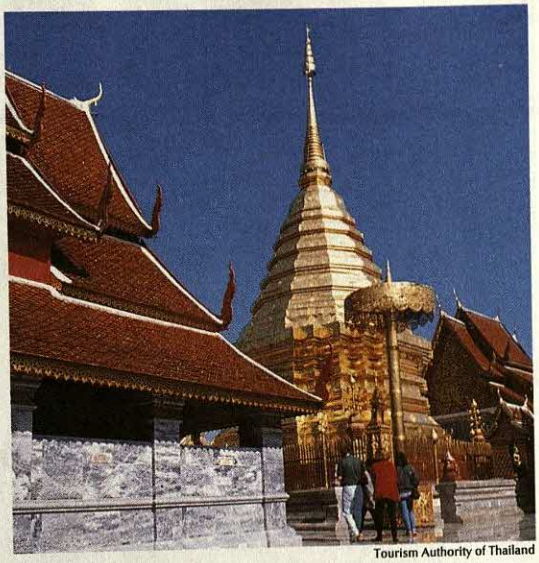
Courts. The Supreme Court, the highest court, consists of a chief justice and 21 judges. The entire court meets only for special cases. The Court of Appeals, the second highest court, reviews decisions made by lower courts. A panel called the Judicial Commission chooses all Thai judges. The judges are approved by the prime minister and formally appointed by the king.

The armed services of Thailand consist of an army, a navy, and an air force. The forces have a total membership of about 300,000. Men from 21 to 30 years old may be conscripted for at least two years of military duty. Women may serve on a voluntary basis.

People

Population and ancestry. For the total population of Thailand, see the *Facts in brief* table with this article. About 75 per cent of the people live in rural areas, and only about 25 per cent live in towns and cities. In addition to Bangkok, which has almost 6 million people. Thailand's largest cities include Khon Kaen, Nakhon Ratchasima, Nanthanburi, and Songkhla, each with a population over 200,000.

Most of Thailand's people belong to the Thai ethnic group. Chinese people make up the second largest population group. The next largest groups consist of Malays and Khmers. Small ethnic groups include the Hmong, the Karen, and other isolated hill peoples, as well as a number of Indians and Vietnamese.



Tourism Authority of Thailand

Wat Phrathat Doi Suthep is a Buddhist temple near Chiang Mai. Its gilded tower dates from the 1300's.

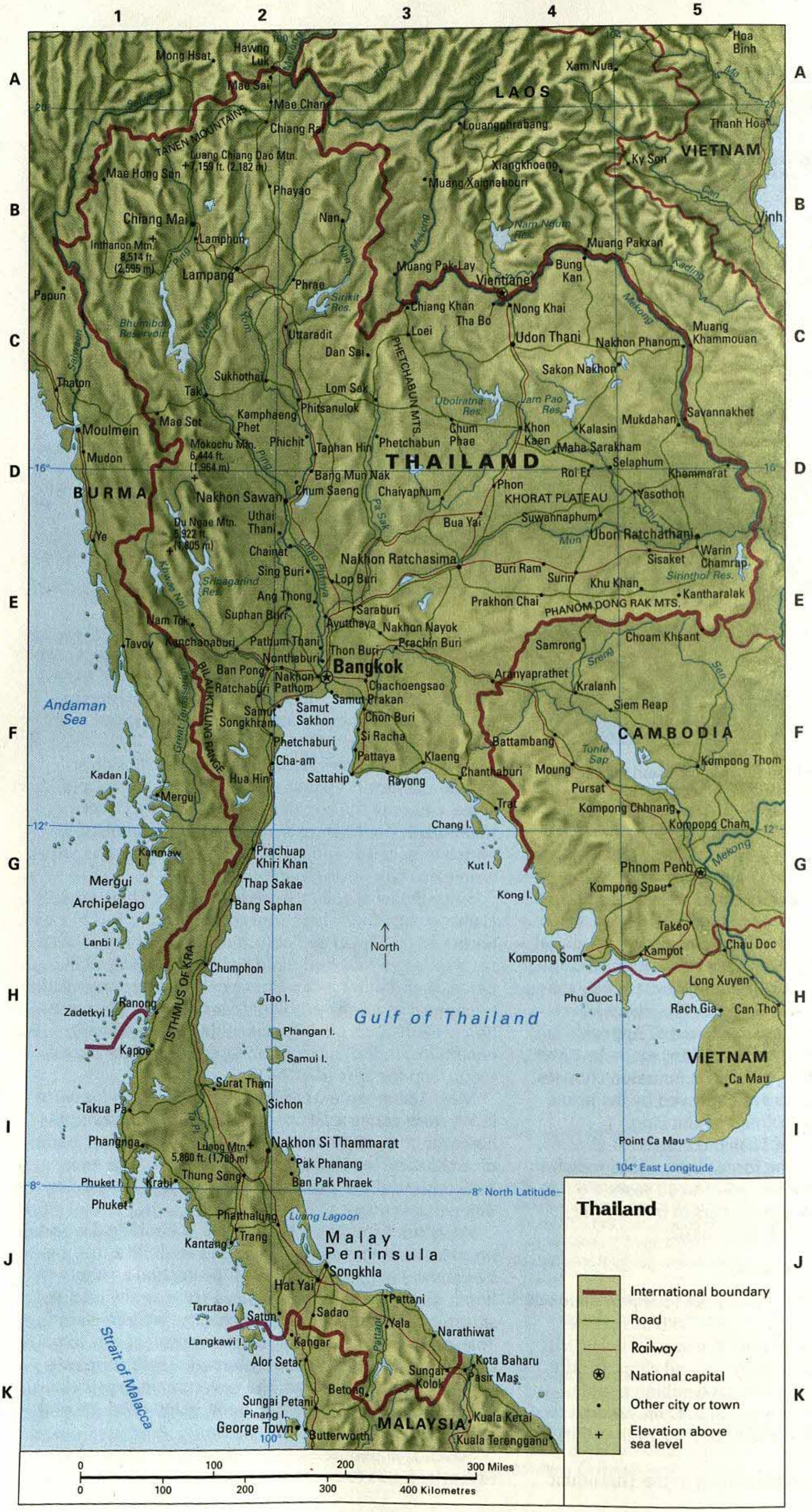
Way of life. Each Thai village has a *wat* (Buddhist temple-monastery), which serves as the religious and social centre of the community. Village life in Thailand traditionally has been organized around religious and agricultural rituals and festivals. But now radio and television also have a strong influence.

Since the early 1960's, large numbers of Thai—especially young adults—have moved from rural areas to cities in search of jobs and educational opportunities. As a result, a large educated middle class has emerged in Bangkok and other cities. However, Thai cities have had to cope with serious problems caused by rapid population growth. Such problems include crowded living conditions, traffic jams, pollution, the growth of prostitution, and the spread of AIDS.

Most Thai people wear the same clothing styles worn in Western countries. For special or formal occasions, however, they often wear traditional Thai clothing made of such fabrics as Thai silk, Hmong embroidery, and *batik* (a special dye process). See **Clothing** (picture: Traditional costumes).

Housing. Most Thai villagers live in traditional wood houses that are on stilts. The houses are built 2 to 3 metres above the ground mainly for protection against floods. In towns and cities, houses are typically made of stucco or concrete and are not on stilts. Middle-class Thai, especially in Bangkok, live in apartments, or large developments of single-family homes. Some shop owners live above their shops. The government provides limited housing for the urban poor, many of whom end up living in slums.

Food. Thai people eat rice with almost every meal. Favourite foods to accompany the rice include hot, spicy



Thailand map index

Cities and towns

Ayutthaya	51,628	E	2
Ban Pak Phraek	22,625	I	2
Ban Pong	25,047	E	2
Bangkok	5,876,000	E	2
Buri Ram	25,899	E	4
Chachoengsao	37,931	F	3
Chaiyaphum	20,932	D	3
Chanthaburi	30,242	F	3
Chiang Mai	167,000	B	1
Chiang Rai	40,641	A	2
Chon Buri	50,070	F	3
Hat Yai	98,091	J	2
Hua Hin	30,415	F	2
Kalasin	22,152	D	4
Kamphaeng Phet	20,200	D	2
Kanchanaburi	29,502	E	2
Khon Kaen	206,000	D	4
Lampang	43,112	B	2
Lop Buri	36,928	E	3
Mae Sot	18,719	D	1
Maha Sarakham	32,989	D	4
Mukdahan*		D	5
Nakhon Pathom	45,242	F	2
Nakhon Phanom	33,237	C	5
Nakhon Ratchasima	278,000	E	3
Nakhon Sawan	152,000	D	2
Nakhon Si Thammarat	112,000	I	2
Nan	22,564	B	3
Narathiwat	32,146	K	3
Nong Khai	25,032	C	4
Nonthaburi	233,000	E	2
Pattani	32,020	J	3
Pattaya*		F	3
Phatthalung	29,948	J	2
Phayao	24,400	B	2
Phetchabun	23,763	D	3
Phetchaburi	34,597	F	2
Phichit	18,675	D	2
Phitsanulok	73,240	C	2
Phrae	19,872	B	2
Phuket	45,155	J	1
Prachin Buri	20,330	E	3
Ratchaburi	43,316	F	2
Rayong	37,305	F	3
Roi Et	31,223	D	4
Sakon Nakhon	24,491	C	4
Samut Prakan	48,960	F	3
Samut Sakhon	47,697	F	2
Samut Songkhram	30,419	F	2
Saraburi	107,000	E	3
Si Racha	21,651	F	3
Sisaket	19,823	E	5
Songkhla	243,000	J	2
Sukhothai	21,931	C	2
Sungai Kolok	21,917	K	3
Suphan Buri	22,903	E	2
Surat Thani	35,678	I	2
Surin	33,737	E	4
Tak	20,039	C	2
Trang	44,102	J	2
Ubon Ratchathani	137,000	D	5
Udon Thani	81,060	C	4
Uttaradit	33,311	C	2
Warin Chamrap	29,586	D	5
Yala	49,283	J	3
Yasothon	19,007	D	5

Physical features

Bhumibol Reservoir	C	1
Bilauktaung Range	F	2
Chang Island	G	3
Chao Phraya (river)	E	2
Chi (river)	D	5
Du Ngae Mountain	E	1
Gulf of Thailand	H	3
Inthanon Mountain	B	1
Isthmus of Kra	H	1
Khorat Plateau	D	4
Khwae Noi (river)	E	1
Kut Island	G	4
Luang Mountain	I	2
Luang Chiang Dao Mountain	B	1
Luang Lagoon	J	2
Malay Peninsula	J	2
Mekong (river)	C	5
Mokochu Mountain	D	2
Mun (river)	D	4
Nan (river)	B	3
Pa Sak (river)	D	3
Phangan Island	H	2
Phanom Dong Rak Mountains	E	4
Phetchabun Mountains	C	3
Phuket Island	I	1
Ping (river)	B	1
Samui Island	H	2
Srinagarind Reservoir	E	2
Ta Pi (river)	J	2
Tanen Mountains	A	2
Wang (river)	C	2
Yom (river)	C	2

*Population figure unavailable.
Source: 1990 census for the 10 largest
ies; 1980 census for all other places.

stews called curries; salads of meat, fish, and vegetables; stir-fried dishes; and broiled or fried fish with sauces. Delicately flavoured, spicy Thai food has become popular in many parts of the world.

Recreation. Thai people prize the art of *sanuk,* or having fun. The national sport is *muay Thai* (Thai boxing), also known as kickboxing, in which opponents use a variety of strikes with their feet and legs, as well as boxing with their fists. In another popular sport, called *takraw,* the players try to keep a ball made of *rattan* (woven palm stems) in the air by using their heads, legs, and feet. Many Thai enjoy gambling on the lottery, cockfights, and fightingfish contests.

Languages. Thai, the language spoken by almost all people in Thailand, has four main dialects. The Central Thai dialect is the official language and is taught in the schools. Many people in Thailand speak the Central Thai dialect in addition to their own regional or ethnic dialect. Many people also speak Malay or Chinese. English is taught in many schools and is often used in business and government affairs.

Religion. About 95 per cent of the Thai people are Buddhists. Generally, Buddhists believe that people can obtain perfect peace and happiness by freeing themselves from worldly desires. Most Thai people follow the *Theravada* (Way of the Elders) tradition, an ancient form of Buddhism that emphasizes the virtues of monastic life. According to custom, many Thai men become monks for at least a short period, from about one week to several months. They wear yellow robes and lead lives of poverty, meditation, and study.

Most Chinese in Thailand follow Confucianism in addition to practising other religions. The majority of Thailand's Malays are Muslims. Hinduism is the main religion among Indians in Thailand. Only about 1 per cent of the nation's people are Christians.

Education. More than 85 per cent of Thailand's people 15 and older can read and write. Thai law requires children to attend school from age 7 to 14. The government provides free public education, but some students attend private schools. Only a small percentage of Thai students continue schooling beyond the required years. Thailand has 15 universities, several large institutes of technology, dozens of teachers' colleges, and numerous vocational colleges.

© Horst Gossler, The Stock House

Thai boxing, known as *muay Thai* or *kickboxing,* is the national sport. Opponents fight with their feet as well as their hands.

Arts in Thailand are greatly influenced by Buddhism. The country's Buddhist temples display some of the finest Thai architecture. The image of Buddha appears in many Thai paintings and sculptures. Modern Thai painting includes traditional religious themes and international styles.

Traditional Thai literature was written and performed for royalty and consisted of classical dramas and epic poems. Today, Thai classical dancers wear spectacular costumes and act out such traditional legends in performances called *khon* drama.

Land

Thailand covers 513,115 square kilometres. The country has four main land regions: (1) the Mountainous North, (2) the Khorat Plateau, (3) the Central Plain, and (4) the Southern Peninsula.

The Mountainous North. Mountains occupy part of northern Thailand and extend along the country's western border to the Malay Peninsula. Inthanon Mountain, Thailand's highest peak, is in this region. The mountain rises 2,595 metres above sea level. Forests of evergreen

Saul Lockhardt, Advertasia Co., Ltd.

Middle-class housing in Thailand consists mainly of small, single-family dwellings. These houses belong to a housing development in a suburb of Bangkok.

Saul Lockhardt, Advertasia Co., Ltd.

Thai classical dancers act out traditional stories with religious themes. Jewels and embroidery decorate their costumes.

trees and some broadleaf trees, such as teak, cover most of the region. The mountains are broken by rivers running south. These rivers form narrow, fertile valleys where farmers grow rice and other crops.

The Khorat Plateau, also known as Isan, lies in the northeastern part of Thailand and makes up about one-third of the country's land area. Mountain ranges separate the plateau from central Thailand to the west and Cambodia to the south. The Mekong River forms the region's northern and eastern boundaries. Two other rivers, the Chi and the Mun, also run through the region. But generally, the area is dry with sandy soil that makes poor farmland.

The Central Plain extends from the foothills of the north to the Gulf of Thailand. Its soil is so fertile that farmers raise more rice there than anywhere else in Thailand. Four rivers—the Nan, Ping, Wang, and Yom—unite in the plain and become the Chao Phraya River. The Chao Phraya, Thailand's main river, provides both irrigation and transportation.

Edward S. Ross

The Mountainous North region includes Thailand's highest peak, 2,595-metre Inthanon Mountain, *background.* In the foreground is a dwelling of the region's Hmong people.

The Southern Peninsula shares its northwestern border with Burma and extends south to Malaysia. This region of Thailand consists mainly of jungle and mountains. Narrow plains run along the coast. Fishing, rubber production, and tin mining in the region contribute much to the Thai economy.

Animal life. Thailand's forests once abounded with tigers, wild pigs, deer, crocodiles, king cobras and other snakes, and many varieties of birds. But since the mid-1900's, many species of wildlife in Thailand have become endangered. These animals are threatened with extinction, in part because thousands have been killed for profit. In addition, agriculture and industry have destroyed many of Thailand's forests. In the past, many elephants lived in the wild in Thailand. Today, however, most of the country's remaining elephants live in captivity. Some Thai families make pets of such wild animals as monkeys, catlike mammals called civets, and squirrels.

Climate

Thailand has a tropical climate. Most of the country has three seasons—a hot, dry season from March to May; a hot, wet period from June to October; and a cool, dry season from November to February. Bangkok has an average temperature of 25 °C in December and 30 °C in April. The mountain areas are cooler.

From late May to October, winds called *monsoons* cause heavy rains throughout Thailand. The Southern Peninsula region may receive more than 250 centimetres of rain in one year. Bangkok has an average annual rainfall of 140 centimetres.

Economy

Thailand's economy developed rapidly in the 1980's and early 1990's. Today, Thailand has one of the fastest growing economies in the world.

The Thai economy is based on free enterprise, in which businesses operate largely free of government control. About 65 per cent of the nation's workers make their living by farming or fishing, and only about 10 per cent work in manufacturing. However, manufactured goods contribute more to the national income than agricultural products do. Government, education, trade, transportation, and other service industries employ large numbers of people in Thailand. Other Thai people work in construction and mining. Forestry, especially the harvesting of teak, was formerly important to Thailand's economy. But the government banned logging in 1988 because too many trees had been removed.

Agriculture. Farmland makes up about 45 per cent of the nation's land. The chief crop is rice. Other leading farm products include *cassava* (a potatolike plant used to make tapioca), cotton, *jute* (a fibre plant used in making rope and sacks), maize, pineapples, rubber, silk, soybeans, sugar cane, and tobacco. Farms in Thailand average about 4 hectares, and about 75 per cent of the farmers own their land.

Manufacturing first gained importance in Thailand in the 1970's, when the Thai government began expanding industries that would increase international trade, particularly with Japan. Thailand's main manufactured products include cars, cement, electronic goods, food products, plastics, and textiles.

Fishing has always been a mainstay of the Thai economy. Many farmers raise fish in ponds. Commercial fisheries in the south and southeast fish by *trawling,* pulling a funnel-shaped net through the sea. Fisheries also raise shrimp and other shellfish for sale worldwide.

Mining. Tin and zinc are Thailand's most important minerals. The nation ranks among the world's leading tin producers. Thailand also has copper, iron ore, and lead. Large amounts of natural gas lie under the Gulf of Thailand. Rubies and sapphires are mined in central Thailand, and many other precious stones are brought in from Cambodia and Burma.

Tourism contributes greatly to Thailand's national income. Millions of tourists visit each year to see the country's magnificent temples, interesting historical sites, beaches, and exciting night life.

International trade. Chief exports of Thailand include electronic goods, fish products, precious stones, rice, rubber, sugar, tapioca products, textiles, and tin. The nation's major imports include car parts, chemicals, fertilizers, fuels, iron and steel, and machinery. In the past, Thailand relied on the United States for much economic support. But today, Thailand carries on brisk trade with other Asian nations as well. Germany, Japan, Singapore, and the United States rank as its main trading partners.

Transportation in Thailand includes extensive road and railway systems. Bus lines reach nearly every part of the country, and the state-owned railways fan out in all directions from Bangkok. Rivers and canals in Thailand provide local transportation for passengers and cargo. Bangkok is the country's largest and busiest port. The city struggles with major traffic problems caused by rapid population growth.

Bangkok International Airport provides daily flights between Thailand and other Asian nations, the United States, various European countries, and Australia. Several other Thai cities have international as well as domestic air service.

Communication. Thailand has dozens of daily newspapers, many of which are published in Bangkok. Most of the newspapers are published in the Thai language. Several are in Chinese, and a few are in English. The newspapers are privately owned. However, the government runs nearly all of the television and radio stations. Telephone services link most cities and towns, but many rural residents still lack phones.

History

People have lived in what is now Thailand for thousands of years. By the A.D. 1000's, people known as the Tai had begun migrating from what is now southern China into mainland Southeast Asia. There, the Tai came in contact with Mon and Khmer peoples who had long lived in the region. The Tai adopted Buddhism from the Mon and many Hindu practices from the Khmer. Foreigners began calling this region Syam as early as the 1000's. Later, the area became known as Siam and its people Siamese, still hundreds of years before the country officially adopted that name.

Early kingdoms. The people of Thailand date their history from the founding of a kingdom called Sukhothai in 1238. The Tai people who had established the kingdom began calling themselves the Thai, meaning *free.* Sukhothai's most famous ruler, King Ramkhamhaeng, reigned from about 1279 to 1317 and greatly expanded the Thai territory. Historians also credit Ramkhamhaeng with developing a writing system for the Thai language. A form of his alphabet is still used today.

In 1350, the Thai kingdom of Ayutthaya was established. The capital, also called Ayutthaya, sat on an island in the Chao Phraya River, an ideal place for trade and defence. Within a century, Ayutthaya became more powerful than the kingdom of Sukhothai.

European contact began for the Thai in 1511, when Portuguese traders settled in Ayutthaya. During the next century, Dutch, English, Spanish, and French traders and missionaries entered the area. Ayutthayan kings also

Chinteik Electronic Industries Co., Ltd.

Electronic equipment is manufactured in Thailand. Above, a worker operates machinery that produces integrated circuits—devices used in such equipment as computers and televisions.

Charles Marden Fitch

Tin mining contributes greatly to Thailand's international trade. Most of the country's tin mines, including the one shown here, are in the mountains of the Southern Peninsula region.

allowed settlements of Chinese and Japanese and sent government representatives to countries as distant as France and the Netherlands. However, many Thai became alarmed at the foreigners' growing influence in their kingdom. Partly as a result, Ayutthaya began to limit its relations with the West after 1688.

Throughout much of its over 400-year rule, Ayutthaya was at war with its neighbours—the Khmer to the east and the Burmese to the west. The Burmese, Ayutthaya's chief enemy, destroyed the capital in early 1767.

The Bangkok era. In late 1767, a military commander named Taksin drove out the Burmese and established a new Thai capital at Thon Buri, on the west bank of the Chao Phraya River. Taksin brought to the region many Chinese traders who helped rebuild the country's economy. After Taksin was overthrown in 1782, a general known as Chaophraya Chakri became king and ruled for 27 years. The new king took the name Rama I and established the Chakri *dynasty* (line of rulers), which still reigns today. During his reign, the capital was moved across the Chao Phraya River to Bangkok.

Modernization gained speed under two of the Chakri dynasty's most influential monarchs, King Mongkut and King Chulalongkorn. Mongkut, also known as Rama IV, ruled from 1851 to 1868. Before taking the throne, Mongkut had served as a monk for 27 years and had led a movement to reform Thai Buddhism. He also studied Western languages and science and, as king, appointed Western advisers to his court. The musical comedy *The King and I* is based on the journals of a British governess whom Mongkut hired to teach his children. The musical portrays Mongkut as a comic figure, and most Thai people consider it a distortion of history.

Mongkut signed many treaties with Western powers, greatly expanding trade and other relations that had been severely limited for over 100 years. The Western powers established several colonies in Southeast Asia. Siam was never colonized, but Mongkut was forced to grant the Western countries *extraterritorial rights.* These rights allowed them to set up courts of law for their people in Siam.

King Chulalongkorn (Rama V), who reigned from 1868 to 1910, is regarded as one of Thailand's greatest kings. With the help of several of his brothers in key government positions, Chulalongkorn furthered Thai modernization. He oversaw a complete reorganization of the government, which included establishing a cabinet to help the monarch rule. He also abolished slavery in Siam, introduced a modern school system, and built railways and telegraphs linking the country.

King Vajiravudh, or Rama VI, succeeded Chulalongkorn in 1910. Under him, Siam entered World War I in 1917 to help France, the United Kingdom, and the other Allies against Germany and Austria-Hungary. In return for Siam's support, Western powers gradually agreed to give up their extraterritorial rights. When King Vajiravudh died in 1925, the throne passed to his brother Prajadhipok, or Rama VII.

Changes in government. In mid-1932, a group of Thai, many of whom had been educated in Europe, revolted against King Prajadhipok. Pridi Phanomyong, a lawyer, and Phibun Songkhram, an artillery officer, led the revolt. They forced the king to change the government from an absolute monarchy to a constitutional monarchy in late 1932, thus limiting the power of the king.

After the coup, a civilian government initially ruled Thailand. But from 1933 to 1938, the military increased its power. King Prajadhipok gave up the throne in 1935 to his nephew, Ananda Mahidol (Rama VIII). Phibun became prime minister of Thailand in 1938 and ran a military government. The country's name was changed to Thailand in 1939.

In World War II (1939-1945), Germany, Japan, and other Axis powers fought the Allies, who included China, the Soviet Union, the United Kingdom, and the United States. In 1941, Japan invaded Thailand. Japan planned to use Thailand as a base to attack Burma, Malaya (now part of Malaysia), and Singapore, three countries then under British rule. At first, Thailand resisted. But Phibun decided to cooperate, and Japan took over Thailand's harbours, airports, and railways.

As the war progressed, the Thai people began to resent Japanese control. Thailand's external trade halted, and the Thai economy suffered. In 1942, some Thai officials began a Free Thai Movement to work against the Japanese. With the support of Allied countries, the Free Thai gained influence within the Thai government. The National Assembly forced Phibun out of office in 1944.

Opposition to Communism. From 1944 to 1947, Thailand had civilian-led governments. The country's name was changed back to Siam for a few years after World War II ended. In 1946, King Ananda Mahidol was found dead of a gunshot wound. Some people believe his death was an accident, and others believe he was assassinated. His brother Bhumibol Adulyadej, also called Rama IX, became king.

Thailand came under military dictatorship from 1948 to 1973. During this time, Phibun and a series of other military leaders ruled. Worldwide, this period marked the height of the Cold War, an intense rivalry between Communist and non-Communist nations. Under military rule, Thailand increased its opposition to Communism and strengthened its alliance with the United States. The United States provided Thailand with much economic and military aid, and Thailand allowed the United States to use military bases on Thai territory. The United States used these bases to attack Communist forces in North Vietnam, Cambodia, and Laos during the Vietnam War (1957-1975). Also during this war, Thailand sent troops to fight on the side of the United States.

In 1967, Thailand, Indonesia, Malaysia, the Philippines, and Singapore formed the Association of Southeast Asian Nations (ASEAN). ASEAN promotes economic, cultural, and social cooperation among its members.

Democracy gains strength. In 1973, university students in Thailand led a successful revolt against the Thai government. They demanded democratic rights and an end to military dictatorship. For the next three years, Thailand experimented with parliamentary democracy. However, in October 1976, the military again seized power after violent student demonstrations took place in Bangkok. Numerous students were killed, and many others fled to the jungle, where they joined Communist forces. From 1976 to 1979, the military continued to rule Thailand, but with more openness to democratic policies.

From 1980 to 1991, Thailand's governments were democratically elected, but the military maintained much power. General Prem Tinsulanonda became prime minister in 1980 and continued Thailand's openness to democracy. About a million refugees had fled to Thailand from Cambodia, Laos, and Vietnam after the Vietnam War ended in 1975. Prem's government provided Thailand with the political stability it needed to temporarily shelter these newcomers until many of them returned to their homes in the early 1990's. Political stability also helped Thailand develop a strong, rapidly growing economy. In the late 1980's, the Thai economy grew by an average of 12 per cent per year, one of the highest growth rates in the world.

In February 1991, the military took control of the government, dissolved the National Assembly, and suspended the Constitution. Thailand adopted a new constitution later that year. In March 1992, a group of promilitary parties won control of the National Assembly in parliamentary elections, and a general was appointed prime minister. Many Thai protested at this appointment. New elections took place in September, and the leader of a group of civilian parties became prime minister.

In 1994, the Friendship Bridge opened between Thailand and Laos. It is the first international bridge to span the Mekong River.

Related articles in *World Book* include:

Asia (pictures: A Buddhist monk; River transportation)
Association of Southeast Asian Nations
Bangkok
Bhumibol Adulyadej
Buddhism
Chiang Mai
Clothing (pictures: Religious clothing; Traditional costumes)
Hmong
Mekong River
Phuket
Southeast Asia Treaty Organization

Outline

- **I. Government**
  - A. National government
  - B. Local government
  - C. Politics
  - D. Courts
  - E. The armed services
- **II. People**
  - A. Population and ancestry
  - B. Way of life
  - C. Housing
  - D. Food
  - E. Recreation
  - F. Languages
  - G. Religion
  - H. Education
  - I. Arts
- **III. Land**
  - A. The Mountainous North
  - B. The Khorat Plateau
  - C. The Central Plain
  - D. The Southern Peninsula
  - E. Animal life
- **IV. Climate**
- **V. Economy**
  - A. Agriculture
  - B. Manufacturing
  - C. Fishing
  - D. Mining
  - E. Tourism
  - F. International trade
  - G. Transportation
  - H. Communication
- **VI. History**

Questions

How does Buddhism influence the arts in Thailand?
What are some popular Thai dishes?
How did Mongkut change the culture of Thailand?
What types of problems have Thai cities faced?
What industry contributes most to the Thai national income?
How have political parties most often come to power in Thailand?
What is a *wat*? What is *batik*? *Muay Thai*? *Sanuk*?
What is Thailand's major rice-producing area?
What are Thailand's chief minerals? Manufactured products?
How do most Thai people earn a living?

Thalassaemia is a hereditary blood disease that causes anaemia. It occurs chiefly among children whose ancestors came from the Mediterranean area. Thalassaemia also afflicts black Americans and some Asian and Middle Eastern peoples.

The bodies of children with thalassaemia do not produce enough *haemoglobin,* a pigment that gives red blood cells their colour. Haemoglobin also carries oxygen to body tissues. A shortage of haemoglobin deprives the victim's organs of the oxygen they need. Symptoms of thalassaemia are present at birth or appear about six months later. They include pale skin, tiredness, irritability, poor appetite, and retarded growth. The child develops an enlarged heart, liver, and spleen. The disease also deforms and weakens certain bones, especially those in the face.

The severest form of the disease is *thalassaemia major,* also called *Cooley's anaemia.* It occurs in children who inherit the haemoglobin defect from both parents. Victims may die in infancy if not properly treated. Many others die in early adulthood as a result of the build-up of iron, especially in the heart. A milder form of the disease, *thalassaemia intermedia,* occurs in children who inherit a severe form of the defect from one parent or a mild form from both. It is not fatal in most cases. People who inherit the defect from only one parent usually get *thalassaemia minor.* Such individuals are called *carriers* of the disease because they do not have its symptoms but may pass it on to their children.

Thalassaemia cannot be cured. It can be treated by blood transfusions, which keep the patient's haemoglobin at near normal levels. But this treatment causes excess iron to accumulate in the heart, pancreas, and other organs. The deposits of iron can lead to diabetes and heart failure. Researchers are working to develop drugs and techniques to remove the excess iron. A technique called *chelation therapy,* by which drugs are used to remove toxic metals from the body, has improved the long-term outlook for thalassaemia patients. See **Chelation therapy.**

Thales (625?-546? B.C.) was the earliest known Greek philosopher. He was born in Miletus in Asia Minor. All that is known about Thales came from brief and scattered reports by later historians and philosophers.

According to the Greek philosopher Aristotle, Thales was the first philosopher to attempt to discover the underlying material source of all things. Aristotle wrote that Thales believed that this substance was water. He also reported that Thales believed that magnets have souls because of their ability to move iron.

Thales was perhaps the first individual to bring a philosophic and scientific approach to subjects that had previously been given mythological and supernatural explanations. He was the first to use reasoning and observation in attempting to answer questions about human beings and the universe. Thales may therefore be considered the founder of the philosophical and scientific tradition in the Western world.

Thalia. See **Graces; Muses.**

Thalidomide. See **Drug** (Testing with people).

Thallium is a chemical element with symbol Tl. It a soft, bluish-grey metal that looks like lead. Most thallium comes from iron pyrites, in which traces of the element occur as an impurity. It also occurs in the minerals crookesite, hutchinsonite, and lorandite. Sir William Crookes, an English scientist, discovered thallium in 1861.

Thallium has an atomic number of 81 and an atomic weight of 204.383. It melts at 303.5° C and boils at 1457° (±10°) C. At 20° C, it has a density of 11.85 grams per cubic centimetre (see **Density**). Thallium is quite toxic to human beings. Its toxic effects are *cumulative*—that is, they build up over an extended period of time. Too much exposure to thallium may cause nerve damage, emotional change, cramps and convulsions, and eventually coma and death due to respiratory paralysis.

Thallium and its compounds have various uses. However, these uses are limited because of the chemical's highly toxic nature. A radioactive isotope of the element, Tl-201, is useful for diagnosing certain types of heart disease. The compound thallium sulphate is widely used in ant and rat poisons. Thallium bromide, thallium iodide, and thallium sulphide undergo changes when they are exposed to infrared radiation. As a result, they are used in devices for detecting and measuring such radiant energy.

Thames, River, is the most important river in England. The Thames is also the longest river entirely within England. The Severn, partly in England and partly in Wales, is longer. The Thames flows 346 kilometres from the Cotswold Hills in south-central England to south-eastern England, where it empties into the North Sea. The river serves as a major English trade route. For location, see **United Kingdom** (terrain map).

A number of cities lie along the River Thames, including Oxford, Reading, Kingston upon Thames, London, Tilbury, and Southend-on-Sea. The river winds through the centre of London, passing such famous buildings as the Houses of Parliament and the Tower of London. The Thames measures about 8 kilometres wide at its mouth on the North Sea. The sea's tides affect the lower part of the Thames.

London owes its origin and much of its importance to the River Thames. In London, industries were established on the banks of the river and the city became England's most important trading port. The London docks were built on the river during the 1800's. However, in the 1900's, most of the shipping activity was moved from London to Tilbury. Oil refineries stand at the mouth of the river. A portion of the lower Thames has been *dredged* (deepened by digging up the river bottom) to allow large ships to sail inland from the North Sea.

See also **United Kingdom** (picture: The Houses of Parliament).

Thamesdown (pop. 167,200) is a local government district in Wiltshire, England. Its main town is Swindon, a fast-growing industrial and commercial centre. The traditional engineering industry grew in the 1800's in association with the Great Western Railway. In recent years railway engineering has ceased, and been replaced by motor car engineering. Other important industries are electronics manufacture and warehousing, and company administration. Dairy farming is important in the district's rural areas. Swindon has an award-winning pedestrian shopping area, the Brunel Centre. The town also has a sports complex and theatre. See also **Wiltshire.**

Thane is an Anglo-Saxon title which was used for many years in early England. The word thane had many meanings. At various times it meant servant, attendant, retainer, or official. Early England had a system of thanehood which was similar to the later system of knighthood. Thanehood was open to freemen, not of noble birth, who fulfilled the following conditions: gaining control of a certain amount of land, making three sea voyages, or doing military service.

A thane of ordinary standing received a manor from the lord he served. In time, a successful thane might become an *earl* (member of the higher nobility). In wartime, royal thanes formed the king's personal bodyguard. The title has not been used since the reign of William the Conqueror.

Thanet (pop. 121,700) is a local government district in Kent, England. It occupies roughly the area of the Isle of Thanet, a flat coastal region in the northeastern corner of Kent. The council offices for the district of Thanet are at Margate. Birchington, Broadstairs, Cliftonville, Margate, Ramsgate, and Westgate are all seaside resorts. Broadstairs has associations with novelist Charles Dickens.

The Isle of Thanet measures about 16 kilometres from east to west, and about 8 kilometres from north to south. It is called the *Isle* of Thanet because, in Roman and

The upper reaches of the Thames flow through the peaceful countryside of Gloucestershire and Oxfordshire.

The River Thames flows through the heart of London, past many famous landmarks, such as Tower Bridge, *above.*

Saxon times, it was cut off from the mainland by a channel called the *Wantsum.*

Thanksgiving Day is a day set aside each year for giving thanks to God for blessings received during the year. On this day, people give thanks with feasting and prayer. The holiday is celebrated in the United States and Canada.

The first Thanksgiving Days in the American colony of New England were harvest festivals, or days for thanking God for plentiful crops. For this reason, the holiday still takes place late in the autumn, after the crops have been gathered. For thousands of years, people in many lands have held harvest festivals. The American Thanksgiving Day probably grew out of the harvest-home celebrations of England.

In the United States, Thanksgiving is usually a family day, celebrated with big dinners and joyous reunions. The very mention of Thanksgiving often calls up memories of kitchens and pantries crowded with good things to eat. Thanksgiving is also a time for serious religious thinking, church services, and prayer.

Between 1893 and 1938, Thanksgiving Day in the United States was celebrated on the last Thursday of November. But in 1939, President Franklin D. Roosevelt set it one week earlier. He wanted to help business by lengthening the shopping period before Christmas. The U.S. Congress ruled that after 1941 the fourth Thursday of November would be observed as Thanksgiving Day and would be a legal federal holiday.

Thanksgiving Day in Canada is celebrated in much the same way as in the United States. It was formerly celebrated on the last Monday in October. But in 1957, the Canadian government proclaimed the second Monday in October to be the holiday.

U Thant

Thant, U (1909-1974), a Burmese diplomat, served as secretary-general of the United Nations (UN) from 1962 to 1971. He had become acting secretary-general in 1961, filling the unexpired term of the late Dag Hammarskjöld. U Thant had only one name, as do most Burmese. *U*, a title of respect, has a meaning similar to *Mister.* U Thant was born in Pantanaw, Burma, and attended University College in Rangoon. From 1928 to 1947, U Thant worked as a school teacher and journalist. He strongly opposed colonialism. In 1947, he became Burma's press director. He was named director of broadcasting in 1948. In 1957, U Thant became chairman of the Burmese UN delegation. See also **United Nations.**

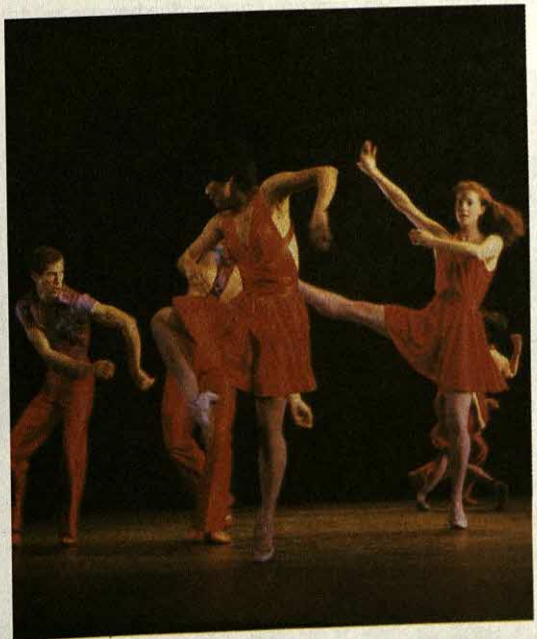
Thar Desert stretches northwest of the Aravalli Range in India across Rajasthan to the Indus River plain in Pakistan. It is also called the Indian Desert. The Punjab region forms its northern limits. For location, see **India** (physical map).

The Thar Desert covers 192,000 square kilometres. Less than 25 centimetres of rain falls there annually. Formerly, few people lived in the Thar Desert. They raised sheep where there was enough water for grass. In 1986, however, the Indira Gandhi Canal was completed and irrigation projects were begun. The projects have attracted some farmers to the area.

The Thar is rich in various types of precious minerals and stones. Pokharan, in the desert, is the site of India's nuclear test facilities. One of India's major nuclear power plants is located in the Thar, at Kota.

Tharp, Twyla (1941-), is an American dancer and *choreographer* (creator of dances). Her work features movements from many types of dance, including ballet, social dances, and tap-dancing. Tharp uses these familiar movements in original ways to create works filled with clever gestures and abrupt, unexpected changes in motion and mood. The energy in the dances makes them seem spontaneous, but every move is carefully planned and her works are structured with mathematical precision.

Tharp has used many kinds of music, including classical, pop, rock, jazz, and ragtime. In the 1960's, she even created dances to be performed in silence. After she established her own company in 1965, she created such important works as *Re-Moves* (1966), *Medley* (1969), and *Eight Jelly Rolls* (1971). Her later works reflect a mood of self-examination and pessimism, as in *Short Stories* (1980) and *Fait Accompli* (1984). She choreographed *Deuce Coupe* (1973), *As Time Goes By* (1973), and *Deuce Coupe II* (1975) for the City Center Joffrey Ballet. She created *Push Comes to Shove* (1976) for the American Ballet Theatre. In 1988, Tharp joined the American Ballet Theatre as a resident choreographer and artistic associate. Tharp choreographed the films *Hair* (1979) and *Amadeus* (1984). She was born in Portland, Indiana, U.S.A.


A Twyla Tharp dance, *Deuce Coupe,* presents dancers performing to the rock music of the Beach Boys. Tharp has choreographed works to classical music and jazz as well as rock.

Thatcher, Margaret (1925-), was prime minister of the United Kingdom from 1979 to 1990. In 1991, she was elevated to the peerage as Baroness Thatcher.

She was the first woman to hold the post of prime minister, and served longer as prime minister than any Briton of the 1900's. Thatcher was elected leader of the Conservative Party in 1975. She became prime minister after her party defeated the Labour Party in a general election in May 1979.

During Thatcher's terms in office, there was some economic expansion in the United Kingdom. This was accompanied by high unemployment and a decline in many manufacturing industries. Thatcher's government transferred many state-owned industries, such as gas, oil, and telecommunications, into private hands. The power of trade unions was reduced by new laws.

In foreign affairs, Thatcher presided over the creation of Zimbabwe, the strengthening of UK nuclear forces, and a military victory over Argentina during the Falklands conflict of 1982. She maintained close links between the governments of the UK and the United States. But she was frequently critical of Britain's partners in the European Community.

Early life. Margaret Hilda Roberts was born in Grantham, in Lincolnshire, England. Her father owned a grocery shop and her mother was a dressmaker before she married. Margaret Roberts and her elder sister, Muriel, had a strict upbringing. Alfred Roberts invested heavily in his children's education. He was a prominent figure in Grantham, serving as a Conservative councillor, alderman, magistrate, and mayor of the town. He was also a lay minister in the Methodist Church.

Margaret Roberts was a good student. At the age of ten, she won a scholarship to Kesteven and Grantham Girls' School. Roberts was also a keen sportswoman. At Kesteven, she was captain of games. She became head girl of the school.

Margaret Thatcher

While studying, Roberts read steadily about politics and world affairs. She spent part of her school holidays serving in her father's grocery shop and attending local magistrates' court hearings. From 1935, she ran errands for the local Conservative Party during election campaigns.

In 1943, Roberts won a scholarship to study chemistry at Oxford University. She was elected president of the university's Conservative Association in 1946. She graduated with a degree in natural science in 1947. From 1947 to 1951, Roberts worked as a research chemist. During this period, she also began to study law in her spare time.

In 1951, Roberts married Denis Thatcher, a former officer in the Royal Artillery who had become a successful businessman. In 1953, Margaret Thatcher gave birth to twins, Mark and Carol. A year later, she completed her law examinations and began practising as a barrister in the fields of taxation and patents.

Political career. Margaret Thatcher entered the House of Commons in 1959 by winning the north London constituency of Finchley. In Parliament, she introduced a bill that was eventually passed and became the Public Bodies Act. This called for a closer watch over public organizations such as educational boards, and permitted the press and public to attend their regular meetings. In 1961, Thatcher was appointed parliamentary secretary to the Ministry of Pensions and National Insurance. She held that post until the Conservatives were defeated in the 1964 general election.

Margaret Thatcher became Britain's first woman prime minister on May 4, 1979. She arrived at No. 10 Downing Street for the first time after accepting the Queen's invitation to form a government.

During her six years in opposition, Thatcher spoke on issues ranging from the economy to transport and energy. Her belief in the free market, self-help, and private ownership of industry all strengthened, and she became increasingly critical of state support for industry.

In 1966, Thatcher made a speech on the Labour government's management of the economy. She criticized the principle of high income tax to pay for public services, arguing that lower direct taxes would help revive the economy. Thatcher pledged that a future Conservative government would lower taxes.

From 1969 to 1970, Thatcher acted as opposition spokeswoman on education. She criticized the introduction of comprehensive schools. Thatcher disliked the schools' interest in equal opportunity, preferring the traditional grammar school system, which, she believed, concentrated on reward for excellence.

In 1970, the Conservatives returned to government, led by Edward Heath. He appointed Thatcher education secretary, her first and only cabinet post before becoming prime minister. Her term in the cabinet was controversial. Late in 1970, she launched a government programme to raise the price of school lunches and end the provision of free milk. She also reduced funds for colleges and universities, and tried to set new legal limits on the political freedom of students' unions. Unable to halt the comprehensive programme, Thatcher campaigned for educational authorities to be able to preserve independent schools and parental choice.

In 1974, the Conservatives lost office. Appointed as a party spokeswoman on the economy, Thatcher soon became a leader of its radical right wing. She argued for increased home-ownership, a feature of her later policies as prime minister. However, her suggestion that housewives should hoard food to limit the effects of inflation was unpopular with her party. It was seen as unworthy of the traditions of the Conservative Party.

At the end of 1974, Thatcher began to challenge for the party leadership. Her campaign amounted to a revival of middle-class values. Thatcher emphasized competitiveness and profitability in industry, personal responsibility, low direct taxation, and a cut in government borrowing. In February 1975, after two rounds of voting, Thatcher defeated Heath and his supporters to take the party leadership.

From 1975 to 1979, Thatcher, as leader of the opposition, repeated her promise to pursue "sound-money" policies to reduce inflation and streamline the economy. Her speeches coincided with an increase in public sector strikes and economic strain. In 1979, Thatcher became prime minister after a victory over Labour in the general election.

Prime minister. Thatcher's first government, from 1979 to 1983, tightened monetary policy, allowed unemployment to rise, and scrapped price controls, in an attempt to restore free market forces in the UK economy. Inflation, interest rates, and the exchange value of the pound sterling all rose. Public opinion polls indicated that by the end of 1981, Thatcher had become one of the least popular British leaders on record. Thatcher's government had, however, launched its programme of *privatization* (selling state-controlled companies to the private sector), and of permitting the sale of homes owned by local councils to their tenants.

In April 1982, Argentinian military forces occupied the British-run Falkland Islands in the South Atlantic, after a long-running dispute over sovereignty. Thatcher sent a task force to reclaim the islands. In June 1982, after serious losses on both sides, the Argentinian commanders surrendered. The victory transformed Thatcher's position in Britain. In the general election of 1983, she led the Conservatives to a sweeping victory over the Labour Party. Her campaign was based on national pride and opposition to unilateral nuclear disarmament.

In 1985, the country's miners abandoned a year-long strike after the Thatcher government refused to revise the National Coal Board scheme for mine closures.

In 1986, Thatcher is reported to have considered resigning over a cabinet crisis known as the Westland Affair. The government was divided over securing American or European financial support for Westland, a British helicopter company. The issue raised serious questions about Thatcher's style of leadership. Two senior cabinet ministers on opposing sides of the dispute resigned. There were also questions about the integrity of the prime minister's officials.

By 1987, Thatcher's government had privatized the gas, oil, airline, telecommunications, and shipbuilding industries; legislation had curbed the power of trade unions, and the profitability of companies was rising steeply. Thatcher won a further victory in the general election that year. This was the first time a British political leader had won three successive national elections.

In foreign affairs, Thatcher agreed to the establishment of the Lancaster House conference in London. This was to determine the future of Rhodesia, one of Britain's African colonies. Robert Mugabe was elected prime minister of the country, which changed its name to Zimbabwe after independence. In 1984, Thatcher became the first western leader to receive Mikhail Gorbachev before he became leader of the Soviet Communist Party. In 1985, the Thatcher government signed a treaty with China which pledged to maintain the capitalist economy of Hong Kong, a British colony, for 50 years after its return to Chinese sovereignty in 1997.

A number of policy decisions by the Thatcher government produced lasting controversy. Besides the Falklands conflict, they include Thatcher's personal decision in 1986 to allow U.S. military aircraft based in the UK to take part in an attack on Libya. In 1989, the repatriation of Vietnamese refugees in Hong Kong received almost universal condemnation. Throughout the 1980's, Thatcher set herself against all the other Commonwealth governments by opposing economic sanctions against South Africa. In the European Community (EC), she strongly supported moves to create a free market, while trying to preserve political sovereignty.

During 1990, opposition to Thatcher's leadership grew. Many people, including other Conservatives, objected to her attitude to the European Community and her tendency to make decisions without consulting colleagues. There was widespread opposition to the community charge (also called *poll tax*), introduced in Scotland in 1989 and in England and Wales in 1990. In November, she was opposed on these issues by Michael Heseltine, in an election for the Conservative leadership. She resigned when it was clear that she could not win, and John Major was elected as her successor.

Donald Cooper, Photostage

A successful piece of theatre is dependent on the talents of the director, actors, designers of costumes, lighting, and sets, and backstage technicians. Shakespeare's *Julius Caesar* is a powerful drama, seen here in a production by the United Kingdom's Royal Shakespeare Company.

Theatre

Theatre is a live performance before an audience. It includes every form of entertainment from the circus to plays. In more traditional terms, theatre is an art form in which a script is acted out by performers. The performers, usually with the assistance of a director, interpret the characters and situations created by a playwright. The performance takes place before an audience in a space designated for the purpose.

A successful theatrical event is an exciting and stimulating experience, whether it occurs in a purpose-built theatre, a school auditorium, or a space only temporarily being used for theatrical purposes. Spectators as well as those involved in the production feel this excitement. Performances can range from light entertainment, such as musicals and comedies, to the discussion of serious political and philosophical issues.

The word *theatre* comes from a Greek word meaning *a place for seeing.* In this sense, the word refers to the space where performances are staged. However, theatre in a broad sense includes everything that is involved in a production, such as the script, the stage, the performing company, and the audience. Theatre also refers to a part of human culture that began in primitive times.

Theatre is not the same as *drama,* though the words are frequently used interchangeably. *Drama* comes from a Greek word meaning "something done or enacted." From this it came to refer to the stage action and eventually the literary part of the performance—that is, the play. Some critics think a play is not a play until it has been performed before an audience. Others argue that the script is only a blueprint that the director and other interpretative artists use as a basis for performance.

Theatre is one of the most complex of the arts. It requires many kinds of artists for its creation. These specialists include the playwright, performers, director, set designer, costumier, lighting designer, and various technicians. For many productions, composers, musicians, and a *choreographer* (creator of dances) are needed. Theatre is sometimes called a *mixed art* because it combines the script of the playwright, the environment created by the scene designer, and the speech and movement of the performers.

In the earliest theatrical performances, the dramatist performed all artistic functions, including writing the script, acting, and directing. Gradually, specialists developed and the various theatre arts emerged. The actor and the playwright gained recognition first, partly because they needed each other in order to bring their arts to life.

In the modern theatre, a director is used to integrate all aspects of production, including scenery, costumes, lighting, sound effects, music, and dancing. Perhaps the most important job of the director is to guide the performers in their creative process and to aid them in their interpretation of their roles.

This article describes how the theatre arts are used to create a theatrical production. For a discussion of the history of written drama and theatre practices, see **Drama**.

Modern theatre architecture

Most theatre buildings have three basic parts: (1) the auditorium, (2) the stage, and (3) the behind-the-scenes spaces.

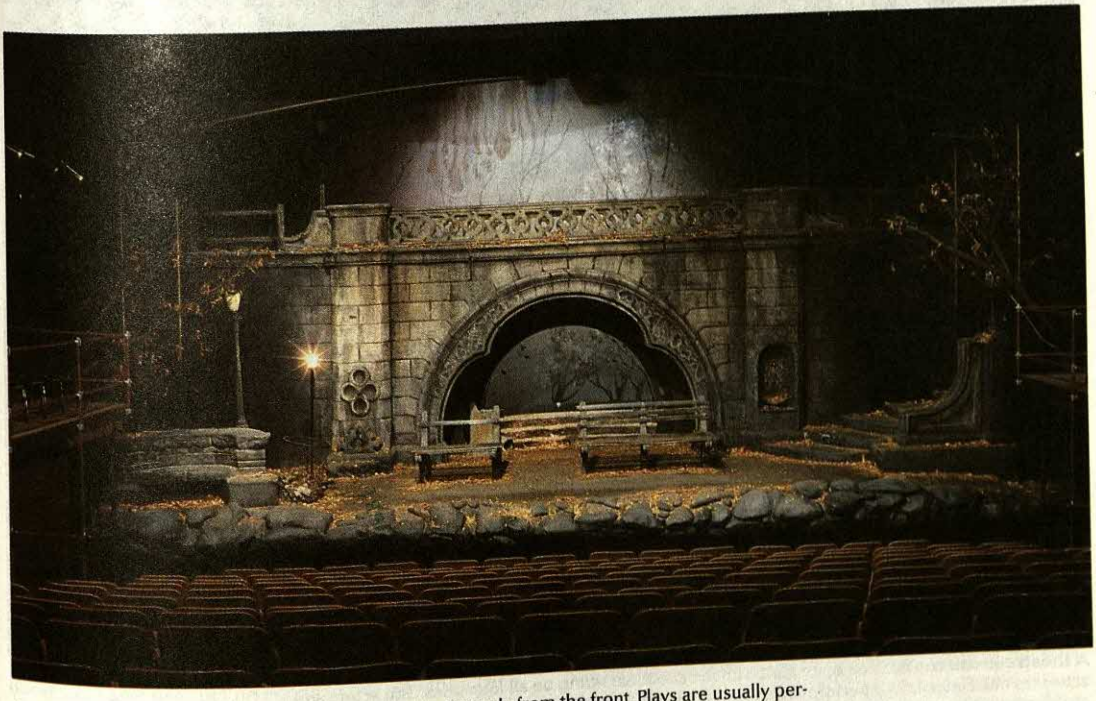
The auditorium is the area of the building where the audience sits during the performance. In the broadest sense, it also includes such facilities as the box office, foyer, entrances and exits, toilets, exhibition areas, and refreshment stands.

A well-designed auditorium has good sight lines and acoustics—that is, it allows every person in the audience to see and hear without strain. It also permits the spectators to reach and leave their seats easily. The interior is decorated in a pleasing fashion that does not distract attention from the stage. Auditoriums may be large or small, and they vary in their basic characteristics. The seats are either all on the main floor, or on the main floor and in one or more balconies. In some older auditoriums, box seats are available on one or more levels close to the stage. The audience normally watches the action of the play from one, two, three, or all four sides. However, in some modern theatres, the audience and the performers share the same space.

In a number of theatres, the seating arrangement for the audience and the location of the performing space change from production to production. In some cases, the audience is required actually to shift location during the performance, moving from one area to another as the action of the performance progresses. In the United Kingdom (UK), presentations that require the audience to shift location, or the actors to move around among the standing audience, are called *promenade* productions.

The stage. There are two distinct types of indoor stage used in the theatre today. In the first type, the acting area occupies a different acoustic space from that of the auditorium. This is called a *proscenium stage*. In the second type, actors and audience share the same acoustic space. This second type of stage is commonly known as an *open stage*.

The *proscenium stage* is the most common type of stage. It is designed to be viewed only from the front. It is sometimes called a "picture frame" stage, because the opening through which the audience sees the action forms a frame for the performers and scenery. This frame is called a *proscenium arch*. An orchestra pit or a forestage area may separate the seats from the area behind the proscenium arch. The musicians can sit in the orchestra pit without cutting off the view of the stage from the audience. Normally, the plays are performed



A proscenium stage permits the audience to see a play only from the front. Plays are usually performed behind a frame called the *proscenium arch*, which encloses the stage area.

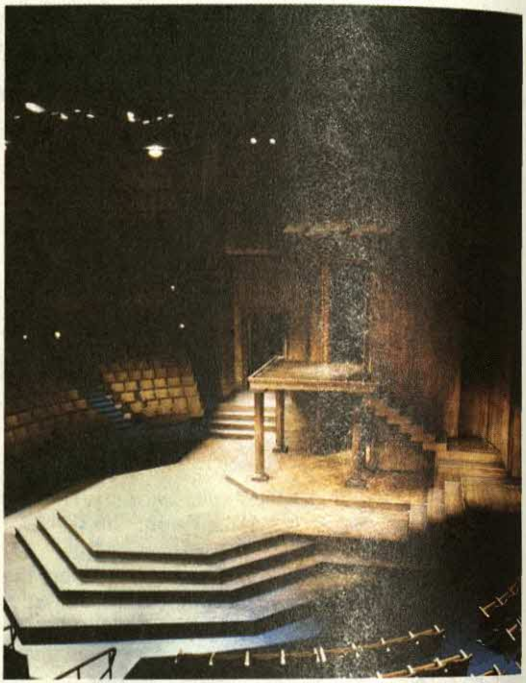
behind the arch, but some of the action may take place on the forestage as well. The audience usually sits in darkness, while the stage, on the other side of the proscenium arch, is brightly lit.

A proscenium stage often has a curtain that may be used to conceal or reveal the stage. The curtain may be closed to permit changes in scenery, to indicate the passage of time, or to mark the act or scene divisions of a play. Today, the dimming of lights often takes the place of closing the curtain. Elaborate, three-dimensional scenery can be used effectively on a proscenium stage. Performers enter or leave the stage by way of openings in the scenery or by way of the *wings* at the sides of the stage.

There are five different forms of *open stage.* They are: (1) the end stage, (2) the thrust stage, (3) the theatre-in-the-round, or arena stage, (4) the traverse, or transverse, stage, and (5) the flexible stage space.

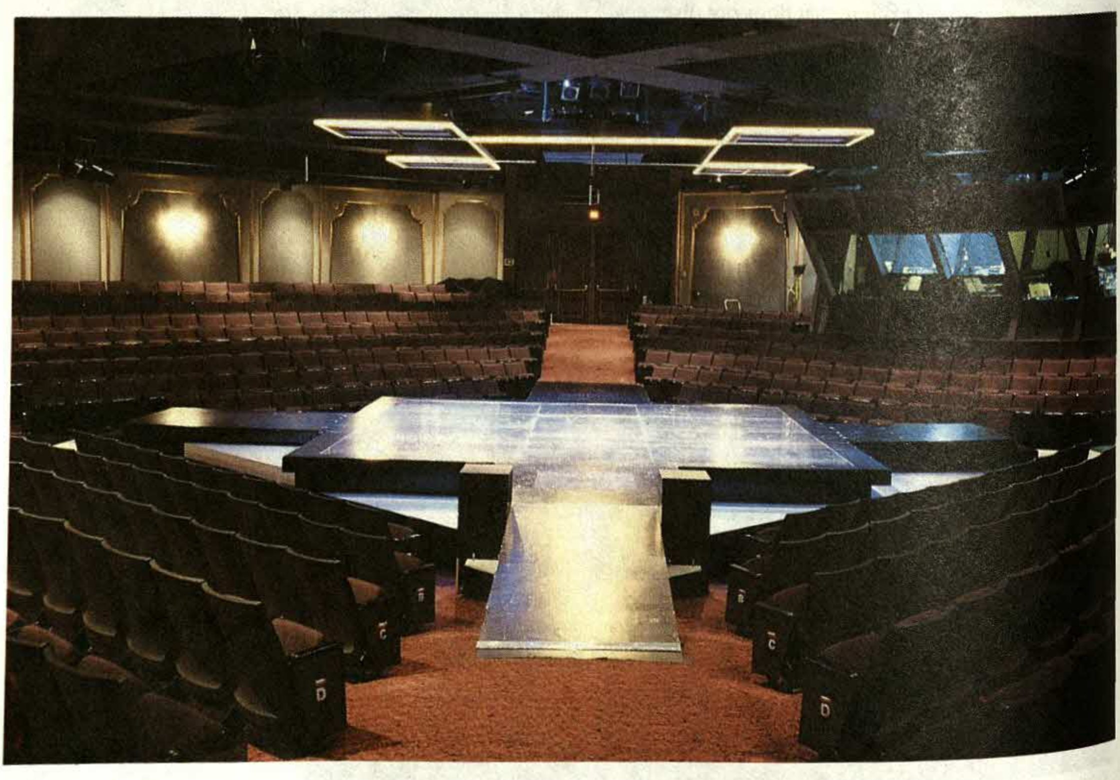
The *end stage* is similar to the proscenium stage. In both types of stage, the action is intended to be viewed from the front. But in the end stage, there is no proscenium arch or conventional curtain, and the whole performance area shares the same space as the auditorium.

The *thrust stage* has seats arranged around three sides of a raised platform that extends into the auditorium. The shape and size of the platform may differ considerably from auditorium to auditorium. Productions presented on open stages must be carefully staged so that all elements can be seen from three sides at the same time. Large units of scenery should be used only at



The Stratford Festival Thrust Stage, Ontario, Canada

An open stage extends into the auditorium on three sides. This stage permits a close relationship between audience and performers, but limits large set pieces to the rear of the stage.



A theatre-in-the-round is an open area with the audience sitting on all four sides. The actors and actresses must adjust their performances so that the entire audience can see and hear. Scenery must be low enough not to obstruct the view of anyone in the audience.

the back of the stage, so they do not block the audience's view.

In a *theatre-in-the-round,* spectators sit on all four sides of the stage and completely surround it. Most stages of this type are found in small theatres with limited seating capacity. The scenery used in a theatre-in-the-round must be low enough to allow the performance area to be seen from every angle. Often it is placed at the end of an aisle or behind the audience. Scene changes are made in darkness or in view of the audience. The performers in a theatre-in-the-round have to make their entrances and exits through the auditorium. They must perform to all sides and must learn to be expressive with the back as well as the front of the body.

In the case of a *traverse stage,* the audience sits on two sides of the performance space. Scenery can be placed at either end of the transverse acting area without obscuring the audience's sight lines. The traverse stage is a form of open staging that works very well with plays where two worlds or forces are in opposition throughout the action.

In a *flexible theatre,* the performance and audience spaces can be rearranged for each production. This adaptability allows a director the freedom of selecting the kind of audience-stage relationship most appropriate to the production. Most flexible theatres accommodate small audiences, and it is not uncommon for the stage area of such theatres to be larger than the space for the audience.

A great deal of theatre today, as in ancient times, takes place in *found spaces*—that is, in areas not originally intended for theatre. Audiences may sit or stand in such spaces, as they do in some flexible theatre. One of the exciting aspects of today's theatre is the variety of its spaces for performers and audiences.

The behind-the-scenes spaces in a fully equipped theatre may include workshops to make costumes and scenery; rehearsal and dressing rooms; lighting and sound booths; storage space for costumes, scenery, properties, and lighting instruments; office space for theatre staff; and a *greenroom* (lounge) for performers. Many professional theatres do not have equipment to build scenery. Many nonprofessional groups work in limited space. Only large organizations have all these behind-the-scenes spaces within one structure, and many groups house work spaces in a building separate from the theatre structure.

The producer

Staging a theatrical production begins with the producer. The producer may be an individual, a group of individuals, or a theatre company. The producer has overall responsibility for the entire show. His or her main duties include one or more of the following: (1) acquiring a script, (2) raising money to finance the show, (3) obtaining a theatre, (4) assembling a creative team to stage the production, and (5) keeping financial records.

Acquiring a script. The starting point for most theatrical productions, professional or nonprofessional, is the playwright's script. A producer who is interested in a new script may take an *option* on it. This gives the producer exclusive production rights to the play for a certain period of time. If the producer decides to present the play, a contract is drawn up specifying the amount of the author's *royalty* (share of the profits). The contract also states the extent of the producer's control over the play. For example, the contract may require the playwright to be available for consultation and possible rewriting during the rehearsal period.

Raising money to stage a play or musical is often the producer's most difficult job. The cost of putting on a theatrical production has become increasingly high. On Broadway in New York City, for example, a play with one set and a small cast may cost several hundred thousand U.S. dollars. Musicals cost well over a million dollars. Few individuals can invest this much money, and so most producers seek funds from many people, groups, or corporations.

Obtaining a theatre. The producer may be a theatre company with its own theatre. If not, the producer must find a suitable space for performances and rehearsals.

In the past, plays destined for London or New York were often presented in other cities before the official opening night. The producer organized theatre hire, transportation, and hotel accommodation. Most out-of-town performances were staged to sample audience reaction as a guide to improving the play and the production. Out-of-town performances are rare today because of the expense involved. Instead, most productions present a series of preview performances in the theatre where the regular performances will be held. Preview tickets are normally sold at reduced prices.

Assembling a creative team may begin before the money is raised. The producer tries to get commitments from a certain director or performer in order to attract investors. After raising the money for the production, the producer helps select and negotiate contracts with all the people involved in the production.

A producer must deal with the trade unions representing various employees. These employees include not only the director, actors, and designers, but also stagehands, musicians, dancers, and box office personnel. Theatre companies normally use their own directors, designers, and performers, but they may supplement their creative team with outside individuals.

Keeping financial records. The producer oversees all expenditure and income for a production. He or she is responsible for seeing that the bills are paid, from salaries and costs of sets and costumes to advertising expenses. The producer also keeps track of the income from ticket sales. Periodically, the investors may inspect the producer's financial records.

The director

In the modern theatre, the director is responsible for the artistic effectiveness of the production as a whole. The director usually decides how the script is interpreted and coordinates the efforts of all the other artists. The director has so much control that theatre in the Western world is often called a director's theatre. However, the best directors are tolerant of the ideas of the other artists throughout the production process.

In traditional theatre production, the director usually has five major duties: (1) analysing the text of the play and determining the interpretation that will shape the production; (2) working with the playwright, technicians, and designers of scenery, lighting, and costumes in planning the production; (3) casting the performers; (4)

supervising rehearsals; and (5) coordinating each element of the final production.

Interpreting the script. The director must be thoroughly familiar with the play in order to cast and rehearse the performers intelligently and guide the various designers. He or she studies the play's structure and examines the devices the playwright uses to tell the story and to build suspense. If traditional structure is not used, as is often the case in modern theatre, the director seeks to discover how the playwright creates a mood and draws responses from the audience. The director often divides the play into sections. He or she then analyses the characters' behaviour and the mood in each section, and determines how each section relates to those before and after it.

The director must understand each character's function in the play and what is demanded of the performers. During the rehearsal process, the director will want to allow input from the actors and actresses. But it is helpful for the director to have an initial sense of each character's personality, physical characteristics, emotional range, and vocal qualities.

The director must have an ability to visualize the scenic, costume, and lighting requirements of a production. He or she will accept ideas from the other partners in the production process, but it is usually the director's responsibility to determine the style and placement of scenery and the appropriateness of the final designs.

The amount of preparation the director must make depends on the play and the production situation. Work on a new play presents problems very different from the demands of reviving a classic. In directing a new play, for example, the director often works directly with the playwright, suggesting changes and cuts. Ideally, this process continues throughout the rehearsal period.

For an older play, the director might wish to make changes in the text so that a modern audience can better understand the language and action. This could involve cutting or changing obscure words or eliminating speeches or entire scenes. Today, such revisions are often made with the help of a *dramaturge.* A dramaturge is usually a historian or literary scholar who advises the director on matters of style or historical detail. Many directors believe that they must try to make a play more meaningful to modern audiences by changing its time and place, or by drastically reinterpreting it. Such approaches may be controversial.

Working with the designers. Before rehearsals, the director discusses the interpretation of the play with the set, costume, and lighting designers. These experts make suggestions about design, and the director may make specific requests. For example, doors and other openings may be needed at particular places on the stage. The director makes sure the proposed settings and costumes reflect the action, mood, theme, characters, and period of the play.

Casting. One of the director's first tasks is to select the performers for all the roles in the play. At this point, a *casting director* is often hired to select finalists for roles. An open audition may be held to which anyone may come. Invitational auditions, to which only certain performers are invited, may also be held.

Actors and actresses auditioning for a role may be given the play to read before the audition. Some directors ask performers to memorize and act scenes from various plays or to present audition scenes prepared by the performer. Other directors require that a performer use pantomime, or they ask the performer to do an *improvisation*—that is, make up a scene on the spur of the moment based on suggestions given by the director.

Casting is the process of filling the play's roles. Performers normally present a short selection for the director, who selects the cast, sometimes in consultation with the playwright.

Many factors determine the final casting. Some roles have specific physical or vocal demands. The emotional range of a role also must be considered. The director tries to cast a role with the other roles in mind in order to create a balanced and varied cast.

Rehearsing. The rehearsal process varies greatly from director to director and play to play. For most traditional directors, there are three major concerns: (1) stage picture; (2) movements, gestures, and facial expressions; and (3) voice and speech. Other directors believe the main concern is to draw the most effective performances possible from the cast by working closely with the performers as a creative partner and by guiding them toward a unified presentation.

Traditional directors believe that each moment of a play should be a *stage picture* in which an image communicates without dialogue with the audience. Each stage picture should have a centre of interest and

The Goodman Theatre production of *The Winter's Tale*

Rehearsing a play includes *blocking,* which establishes the movements of the performers. Most early rehearsals are held in a rehearsal room. Final rehearsals take place on the actual stage.

should express the dominant emotional tone and the relationships among the characters. According to this approach, the director's chief task is to focus the audience's attention on the important elements—usually the one or two characters who are the most important at a particular moment. This is done by manipulating the positions of the performers in relation to the audience and to each other. Today, most directors believe it is a mistake to place too much emphasis on stage pictures—the most mechanical part of directing—while giving too little attention to other aspects of staging.

For example, *movement* is often more vital than stage pictures alone. Movement is essential to blend one stage picture into another and to create a sense of flow and development. Movement must always be appropriate for the character, situation, mood, and type of play. *Gestures* and *facial expressions* supplement the effects of movement. Most problems of *voice* and *speech* are worked out by the performers. But the director serves as a sounding board and makes sure the performers speak clearly and with appropriate expressiveness.

Most early rehearsals take place in a rehearsal room, not on a stage. Chalk lines or tape show the stage floor plan. Only basic furniture and props are used.

A rehearsal schedule for a traditional play normally includes several phases. First, the director and performers read and study the play. Then the director *blocks* action. That is, he or she arranges the broad pattern of the performers' movements, though some of these movements may be changed during later stages of rehearsal. Then detailed work begins on characterization, line readings, stage action, changes in mood, and blending the performers into a unit. Next, problems of lighting, scenery changes, costuming, and other mechanical concerns are resolved. Some directors prefer to rehearse lighting and scenery changes without performers. Finally, in dress rehearsals, the director combines all the elements of theatrical production to present the show as it will be seen by an audience.

The director's assistants include a stage manager and, depending on the budget, one or more assistant stage managers, an assistant director, and a rehearsal secretary. Often, one person serves as both assistant director and rehearsal secretary.

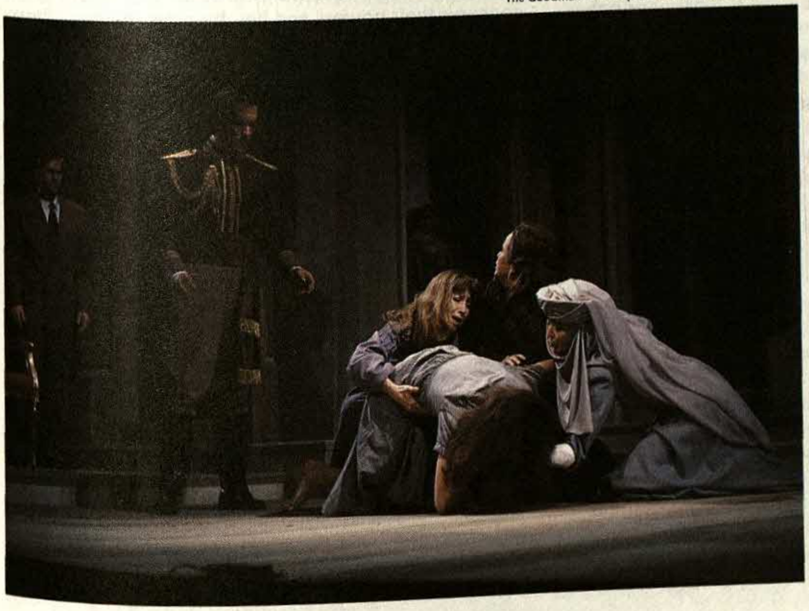
The rehearsal secretary sits near the director during rehearsals and takes notes. An assistant director may rehearse certain scenes, coach performers, or act as a go-between for the director and designers. In the professional theatre, the stage manager organizes auditions. He or she attends all rehearsals, and records changes in dialogue and blocking on a master copy of the script. Later, during performances, the stage manager is in charge backstage. The stage manager may be called upon to direct or rehearse replacement cast members or even a complete cast for a second production of a successful show.

The performers

Performers are among the few artists who cannot separate their means of expression from themselves. They are their own instrument. They create with their own body and voice and their own psychological and mental qualities. It is often difficult to separate talent and creativity from the performer's personality. But acting is an art and, as with any art, natural ability, study, and practice are essential.

Body and voice. Performers need a flexible, disciplined, and expressive body. They must be able to use their body to represent a wide range of attitudes and reactions. They may be aided by courses in stage movement, dancing, or fencing, or by participating in sports that demand physical control and coordination. Dancing and fencing are particularly useful because they provide grace and body control. These skills also assure more job opportunities for performers. A performer who can dance as well as act is especially in demand.

The same requirements of flexibility, control, and expressiveness apply to the voice as to the body. Perform-



The Goodman Theatre production of *The Winter's Tale*

Expressing emotion requires a blend of facial expression and body movement. The grouping and experience of the performers in this scene produce a strong sense of shock and grief. The sharp contrasts in lighting intensify the mood of tragedy.

ers learn how to breathe properly, to achieve variety in vocal rhythm and tone, and to make themselves heard and understood. They also learn dialects. Training in oral reading, relaxation, and singing is important. However, most performers require years of practice to change their voices significantly so that they can speak higher, lower, louder, or softer—and still be understood. For professional performers, therefore, work on vocal improvement, as well as on physical flexibility, should continue throughout their career.

Observation and imagination. To portray a role well, performers should know about human emotions, attitudes, and *motivations* (reasons for behaviour). They must be able to express these elements so that they can be understood by an audience. A good performer develops the habit of observing others and remembering how they behave. If an actor takes the role of an old man, for example, he may prepare in part by observing how old men walk, stand, and sit. He may then adapt these movements to suit the character. A performer also learns how different people react to such emotions as happiness, grief, and fear.

Performers may try to develop *emotional memory,* so that in portraying a role they can recall a situation from their past that caused a similar emotional response in them. This is a complex acting technique, however, and should be used only after developing a thorough understanding of how one should best approach this process. Performers learn to know others through knowing themselves and their emotional capacities as thoroughly as possible. They portray others partly by using their knowledge of themselves and by developing a sensitivity to their own emotions.

Concentration is particularly important for performers. They must be able to involve themselves in an imagined situation and shut out all distractions. Their goal is to give a performance that creates the illusion of something happening for the first time. Part of making this happen involves concentrating on listening to other performers in the play and responding appropriately. It also involves focusing on each moment as it happens rather than anticipating what is to come.

Systems of acting. No matter how talented or even well-trained performers are, they cannot use their skills to full effectiveness without some consistent working method. Performers should try as many approaches to acting as possible, and choose the one, or combination of several, they consider the most successful for them.

The differences among systems of acting are often described in terms of two extremes: *mechanical-external* and *psychological-internal.* The two differ on the question of whether a performer must be emotionally moved to act convincingly. Extreme supporters of the external system argue that emotion may interfere with good acting. They believe the performer should merely try to create the external signs of emotions. Strong advocates of the internal system claim that only through feeling can performers project themselves into a character and situation. This approach is sometimes called the *Stanislavski* system, after the Russian director Konstantin Stanislavski. A version of this approach used in some English-speaking countries is known as the *Method.* For most performers, however, neither extreme provides the best approach to the art of acting or leads to the truthfulness on stage that is most believable to an audience.

Creating a role. Performers must solve several specific problems every time they play a new role, especially in conventional plays. These problems normally include (1) analysing the role, (2) movement and gesture, (3) vocal characterization, (4) conservation and build, and (5) ensemble playing.

Analysing the role starts with a study of the play as a whole. Then performers concentrate on their own parts. First they analyse the various aspects of characterization—a character's appearance, occupation, social and economic status, and general personality. They then examine the character's goal and behaviour, both in the play as a whole and in individual scenes. Finally, they study how their role is related to the other characters and to the structure of the play. If the play takes place during an earlier time, performers may study the period and setting. They not only analyse their role independently, but also develop their interpretation in partnership with the director and the rest of the cast.

Movement and gesture are the ways in which the performer portrays the character's walk, posture, gestures, and bodily attitudes. The director plans the broad pattern of movement or works this out in rehearsal with the actors. The performer fills in the details, working to understand the purpose or emotional reason behind each movement so that he or she can perform every action "in character."

Vocal characterization refers to the character's general vocal qualities. Performers decide what qualities are desirable, and adjust their voices accordingly. One character may require a high-pitched voice. Another may have a soft, soothing voice. The performer also notes the demands of each scene. Some scenes may be relaxed, others may be emotionally high-keyed. A change within a scene can often be enhanced by appropriate vocal patterns. Growing tension can be denoted by raised pitch, greater volume, and faster tempo.

Conservation and build include the ways performers conserve their powers and heighten the role to a climax. In many modern plays, there is no conventional build or climax. However, the performer must still be able to sustain a role and alter its *dynamics* (forces) as needed from beginning to end. Most characters change or show growth during the course of a play, and the performer must reflect these developments. The need to sustain and build a part is most important in highly emotional roles. If performers begin at too high an emotional pitch, they soon may not be able to build the intensity any further. The rest of the performance may seem monotonous. Performers must pace themselves so that the performance grows in strength and interest as dictated by the demands of the text and the decisions made with the director.

Ensemble playing is the sense of artistic unity and cohesion that results from the cooperative efforts of the entire cast. No acting performance is fully effective unless it is integrated with all the other performances—except when the text deliberately calls for a lack of completeness. Ensemble playing results when every performer adjusts to the needs of the play, and remains aware of the methods, strengths, and weaknesses of the other performers.

Set design

Set design has two basic purposes—to aid the audience's understanding, and to express the distinctive qualities of a play. To aid understanding, for example, the stage setting may define the time and place of the action. The set creates an appropriate mood and expresses the play's dominant elements through composition and colour.

The set designer begins a job by studying the play as a whole. He or she then analyses its scenic demands. Consideration must be given to the number, size, and kinds of settings needed; their physical arrangement; and the play's period, place, and social and economic background. The designer also may do research to learn about typical manners and customs, decorative details, architectural forms, furnishings, and building materials of the period.

The designer has a meeting with the director to discuss the kind of stage most appropriate for the production—if choices are available—and the budget for scenery. Also discussed are the requirements of the sets, the locations of entrances and exits, and the arrangement of furnishings.

Next, the designer makes preliminary sketches of the set and discusses them with the director. Before the designs receive final approval, the designer draws them in perspective and in colour. These drawings are called *set renderings.* The designer makes floor plans of each set and may build three-dimensional scale models to show how each set will look and how scene changes can be made. The designer also makes a series of working drawings that show how each set will be built. In the professional theatre, where scenery may be built by a scenic studio, every detail of construction, assembly, and painting must be indicated. In the nonprofessional theatre, where the designer often supervises construction, fewer drawings are needed.

Kinds of scenery. The designer uses several basic scenic units when building sets. Most of these units may be classified as *standing* or *hanging.*

The basic standing unit is the *flat.* A flat is a rectangular wooden frame over which canvas or muslin is stretched, providing a lightweight structure. Flats can be made in any size needed, but extremely large flats are awkward to handle and move. Most flats are from about 3.5 to 5 metres high and 25 centimetres to 2 metres wide. A plain flat has no openings. A door flat, window flat, fireplace flat, and arch flat all have appropriate openings. Other standing units include door and window frames, fireplaces, platforms, steps and staircases, rocks and built-up ground, tree trunks, and columns. A *ground row* is a low flat with a shaped edge that may give the appearance of distant hills, rows of buildings, or even an abstract shape.

Hanging units include *ceilings, borders, backdrops, drapes, curtains, scrims,* and *cycloramas.* Most ceilings are made from two large rectangular flats hinged together. They are suspended above the set, and lowered to rest on the tops of flats representing walls. In modern design, the ceiling often is not used at all. In most exterior settings, borders are substituted for ceilings. Borders are short curtains of black cloth or painted canvas hung parallel to the front of the stage in order to hide the area above the setting from the audience. Borders, like flats, can be shaped and painted to resemble any object or form.

The Goodman Theatre production of *The Winter's Tale*

The set designer, *right,* uses a scale model to demonstrate to the director, *left,* how the set will look and work. After the two agree on the designs, set construction begins.

The Goodman Theatre production of *The Winter's Tale*

Set construction may be handled in the theatre's own workshop or by an outside studio. Generally, each piece of the set is designed so that stagehands can move it easily during the performance.

The Goodman Theatre production of *The Winter's Tale*

A technical rehearsal allows the director and designers to see how the sets, costumes, and lighting look under conditions of an actual performance. Last-minute adjustments may also be made in the play's blocking.

Large pieces of canvas called backdrops or drops, usually extend across the width of the stage. They can be painted to represent any scene. Most drapes or curtains are hung in a series parallel to the proscenium on each side of the stage to conceal offstage space. A scrim is a gauze curtain used for special effects. It appears transparent when lit from the back, but opaque when lit from the front. A cyclorama is a continuous stretched curtain suspended on a U-shaped *batten* (pipe). The cyclorama usually extends along the sides and back of the stage. Most cycloramas are neutral in colour, but they can be made any colour by lighting. They are often used to represent the sky.

Changing scenery. After scenery has been built, it is assembled on stage. A one-set show can be assembled permanently. A multiple-set production, however, requires careful planning so that each unit can be set up and taken down quickly and quietly during the show.

When scenery is changed by hand, each part is moved by one or more stagehands to a prearranged place offstage. New settings are then assembled or moved on stage. Another common method of changing scenery is called *flying.* Suspended units overhead are raised and lowered as needed on the stage.

Rolling platforms called *wagons* or *trucks* are often used to change scenery. Scenery is placed on the wagons, which can be rolled on or off the stage. One kind of wagon is called a *jackknife.* This kind of wagon is attached to the stage floor at a fixed point and moves much as a pocket jackknife opens and closes. A jackknife wagon can be of any size, and it is sometimes as wide as the proscenium opening itself. The most common wagon is a *straight-run wagon* that rolls on stage in a straight line and is pulled back out of sight of the audience for storage.

Scenery can also be changed by means of *revolving stages* or *elevator stages.* A revolving stage has a large circle of the stage floor mounted on a central supporting pivot that can be rotated. Several settings can be erected at one time and moved into view as needed by turning the stage. An elevator stage has sections of the stage floor that can be lowered to the basement of the theatre. There, scenery can be changed while another set is being used.

Properties and set dressing are added to the set after the scenery has been assembled. Properties are often divided into two categories. *Set props,* such as sofas, tables, and bookshelves, function as part of the design or are a necessary part of the setting. *Hand props,* such as fans and guns, are props used by the performers. *Set dressing* includes such items as pictures, curtains, books in a bookshelf, and decorative objects on a mantelpiece.

Lighting and sound

Lighting methods. The lighting designer analyses a play for its dramatic values and then for its lighting needs. The designer notes everything in the script concerning light, including changes in intensity such as a sunrise or lamps being lit. Variations in light may be needed for various parts of the setting. The script may also note the direction from which light enters the set, such as moonlight through a window.

The designer pays particular attention to the mood of the play because lighting is effective in establishing stage atmosphere. He or she must understand the style of the play. For realistic drama, for example, the designer will probably make the light appear to come from a specific source, such as a lamp or sunshine through a window.

The lighting designer confers with the set designer and the director. In the professional theatre, the lighting designer makes sketches showing how the stage will look when lit. In most nonprofessional productions, the lighting designer and the director reach general agreement about lighting. The focus and placement of the lights cannot be finally determined until the scenery is in place.

A lighting control board enables one technician to control all lighting changes from a booth in the theatre. Many of the most complex lighting cues are programmed in advance by computer.

Lighting for the stage is divided into (1) specific illumination, (2) general illumination, and (3) special effects. *Specific illumination* concentrates on a limited area. It is used principally for lighting the acting areas, which require strong emphasis. *General illumination* is used to light the sets and background elements and to blend the lighting of acting areas. In addition, it is used to provide a gradual change between brilliantly lit acting areas and less intense lighting on the background. *Special effects* refers to a variety of lighting techniques and instruments. Typical examples of special effects include projections of clouds, fires, or stars, and the creation of patterns on the stage floor suggesting light through tree branches.

In planning the lighting, the designer draws a *lighting plot* on a floor plan showing the entire stage. A separate lighting plot is sometimes drawn for each set, as well as a plot showing the lighting for all the sets at the same time.

An *instrument schedule* provides a summary of all the technical information needed to set up the lights for a play. This schedule lists lighting instruments, mounting positions, areas to be lit, colour filters, and other technical data.

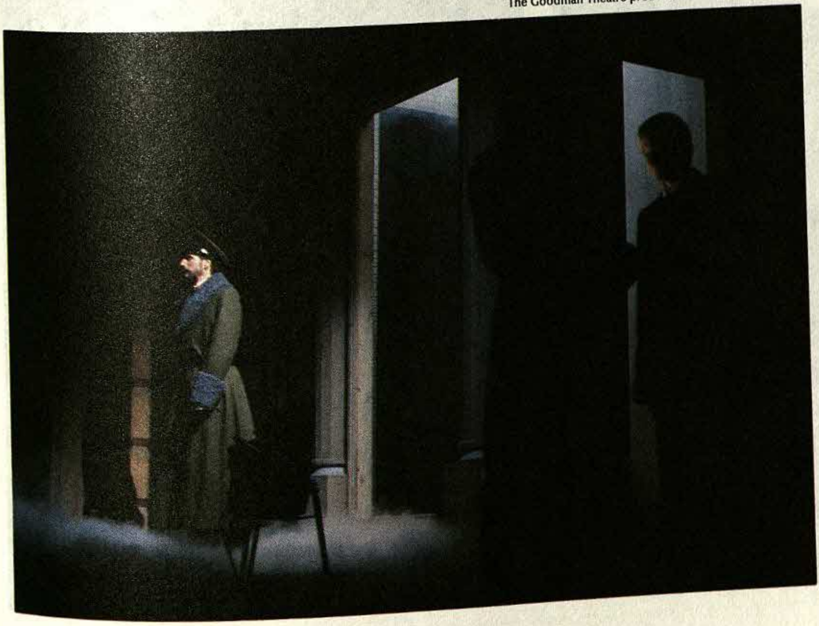
There are several types of lighting instruments. A *spotlight* illuminates a limited portion of the stage with a concentrated beam of light. A lighting assistant may focus a following spotlight on a dancer as he or she moves about the stage. Spotlights commonly range in power from 500 to 5,000 watts. They have reflectors to increase their brightness, and lenses to give light a specific type of edge, either sharp or soft. Frames enable the lighting designer to insert a transparent coloured sheet in front of the lens. This sheet, called a *gelatin* or *gel,* changes the colour of the light.

A *striplight* consists of a series of lamps set in a narrow, roughly rectangular trough. Striplights vary in length, wattage, and use. One type, called *borderlights,* is hung overhead to spread light to the set or background. Other striplights may be placed on the floor or elsewhere on the stage, often behind a ground row, to light a cyclorama or scenic units.

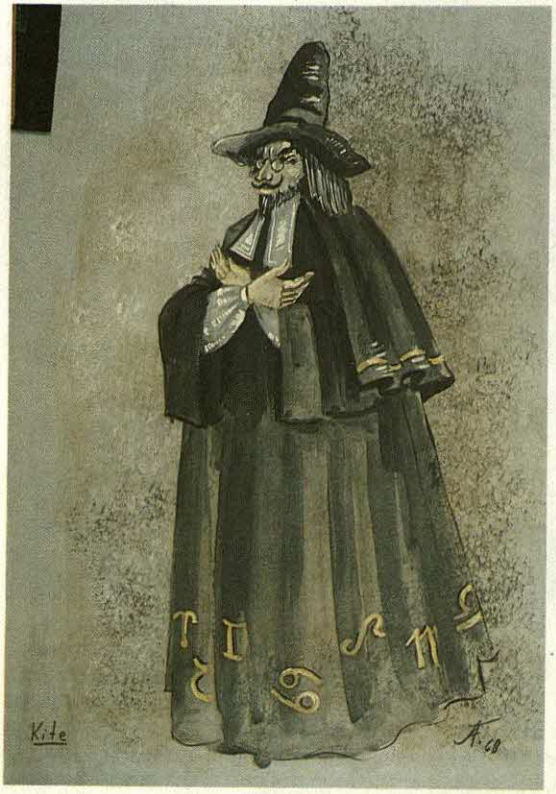
Many instruments are used to create special effects. Projectors for front or rear projection are among the most useful. An entire scenic background can be projected on a screen or on a cyclorama. Some projectors have rotating discs to create the effect of movement, as in clouds.

Lighting on the stage is changed by the use of a number of *dimmers* on a control board. Dimmers allow the designer to vary the intensity of each light, ranging from full brightness to black. Dimmers can change the intensity of the light gradually or quickly. The level of intensity for the lights in each light change, or *light cue,* can be preset during the technical rehearsal. It is common for large numbers of dimmers to be electronically controlled. A complex lighting cue can be accomplished by pushing one key on a computer.

The Goodman Theatre production of *The Winter's Tale*



Lighting plays a crucial part in establishing a play's atmosphere. Lighting can be used to focus an audience's attention on a certain character or part of the stage. The lighting shown on the left helps to create a mood of mystery on stage.



Sound production. Sound makes its greatest contribution when it is designed as a unit and carefully integrated into the production. It includes music, abstract noises, and such realistic effects as thunder.

Sound performs two basic functions: (1) to establish mood and style and (2) to help tell the story. Music and abstract sound help indicate the proper atmosphere for each scene. Such realistic sounds as rainfall or a distant foghorn also contribute to mood. Sound helps tell the story through gunshots, ringing doorbells, and other noises that either prepare the audience for onstage action or indicate action supposedly occurring offstage.

Live sound is created fresh for each performance and includes doorbells and telephones. *Recorded* sound includes noises made by an approaching car and the sounds of a crowd offstage.

Most musicals and some nonmusical plays use microphones to increase or reinforce sound intensity. Technicians wire the microphones across the front of the stage, or the performers wear small hidden microphones that have wireless transmitters to the amplifiers.

Costumes and makeup

Costume design shares the same broad purposes as set design. It aids the audience's understanding and expresses the play's distinctive qualities. Costumes help identify the period and country in which the action takes place and establish the specific location of a scene. They can suggest time of day, season, occasion, and information about the characters—ages, occupations, personalities, and social and economic status.

Costume design begins with a sketch of the proposed costume, *above.* Samples of the material are usually attached. The costume must be fitted correctly, *below left,* so the performer can move freely and comfortably. The costume shown in these pictures is worn by a fortuneteller, *below right,* in George Farquhar's *The Recruiting Officer,* an English comedy written in 1706.

Costumes can clarify the relationships among characters. For example, the warring sides in many Shakespearean history plays are identified by contrasting colour schemes. Costumes also express the overall mood of the play, its style, and the emotional tone of individual scenes.

Like other members of the creative team responsible for a production, the costume designer studies the script thoroughly. The costumier confers with the director, set designer, lighting designer, and principal performers to make sure his or her ideas fit the interpretation of the play. The costumier uses line, mass, colour, texture, and ornaments to create a visual statement. Like the set designer, the costumier records ideas in colour sketches. The sketches, called *renderings,* are usually accompanied by samples of material. They are given to the director for approval. The costumier also makes a chart indicating what each character wears in each scene of the play.

Costumes may be made new, assembled from an existing wardrobe, borrowed, or rented. In the professional theatre, professional costume houses make costumes to order. Nonprofessional theatres often borrow costumes or rent them from a costume rental agency. Many permanent theatre organizations make their own costumes. Most maintain a wardrobe of items from past productions.

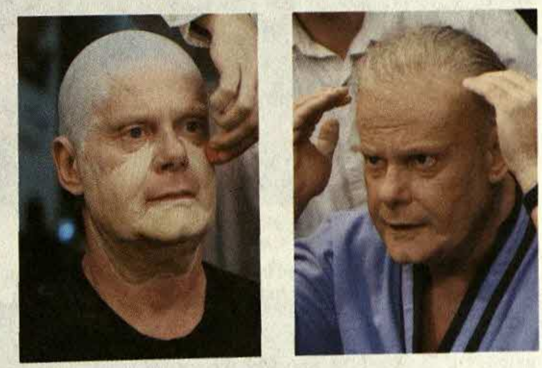
The director and designers evaluate the costumes at a *dress parade,* which shows the performers under lights similar to those used in performances. If there is no dress parade, the evaluation is done during a dress rehearsal. Any necessary changes to costumes are made during the final rehearsal period. After performances begin, a wardrobe attendant works backstage and supervises costume changes, repairs, and adjustments.

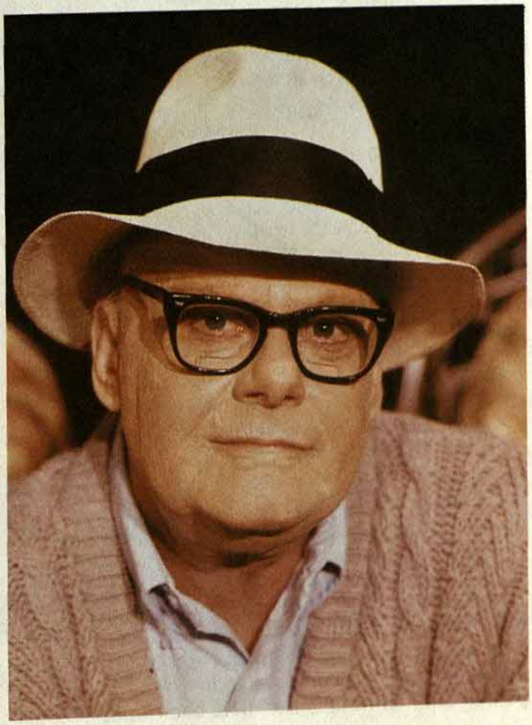
Makeup techniques. Makeup is important in establishing characterization. The appearance of the face indicates the character's age, health, and ethnicity. The face can also suggest a general occupation and basic personality. Makeup is also used to restore or emphasize the face's colour and form, which may be affected by the lighting or distance from the audience.

For a *straight makeup,* the performer's appearance is not changed significantly. In a *character makeup,* it is changed greatly. The makeup may age the face; make it fat, thin, smooth, or wrinkled; or emphasize some peculiar facial characteristic. For a character makeup, the performer may need to alter the hands, the neck, and other portions of the body as well as the face.

Makeup effects can be achieved in two basic ways: (1) by painting or (2) by using plastic or three-dimensional pieces. Painting involves applying colour, shadows, and highlights to the face or body. All makeup has some painted effects. Plastic makeup devices include beards, wigs, false noses, scars, or distorted portions of the face.

Traditionally, makeup has been considered the performer's responsibility, though it also concerns the costumier. In the professional theatre, performers are responsible for their own makeup, but they consult specialists for help with problems. In many nonprofessional theatres, makeup is considered part of the costumier's duties. Sometimes the director is responsible for makeup.





Makeup can be used to alter a performer's appearance. Actor Robert Morse, *right,* and a makeup artist skilfully used makeup, a wig, a hat, and glasses to create a convincing likeness of the American author Truman Capote, *bottom,* for a Broadway show.

Scene from *You Never Can Tell* by George Bernard Shaw

Theatre in Canada has gained international recognition through the productions of the Stratford Festival and the Shaw Festival, both in Ontario. The Shaw Festival, *above,* features the works of British dramatist George Bernard Shaw and other playwrights of the late 1800's and early 1900's.

Theatre around the world

Africa. Traditional forms of African theatre have their roots in the social, religious, and political aspects of tribal societies. Masks, storytelling, puppetry, mime, satire, dance, song, and drumming have all been practised throughout the continent for hundreds of years, serving a variety of tribal purposes. This heritage has shaped the work of numerous modern playwrights whose plays have appealed to national, pan-African, and international audiences alike. Theatre in Africa has thrived since European colonial rule ended. Bernard Dadie, Wole Soyinka, Ngugi wa Thiong'o, and Ama Ata Aidoo are a few names from this exciting and important post-colonial theatre movement.

Although Western-influenced theatre buildings have played an important role in many urban areas, most traditional African theatre is performed outdoors. However, a number of flexible stages, such as that of the Kodzidan (The Story House) at Atwia in Ghana, have been exploited to good effect by modern innovators such as Efua Sutherland.

More often than not, African theatre audiences go to a performance not to watch but to take part. Audience participation plays an important part in aiding the development and liberation of communities. Such participatory theatre has a prominent place in contemporary Africa. This is shown in the work of Zakes Mda in Lesotho and of Penina Mlama in Tanzania. In North Africa, similar participatory forms of theatre have been pioneered, particularly by the Algerian playwright and director Kateb Yacine.

America. North and South America play host to several theatrical traditions. Each tradition has its origins in the culture of the immigrants who first brought it to the New World. But the experience of living in and being part of the Americas has helped produce a genuine theatre of the Western Hemisphere.

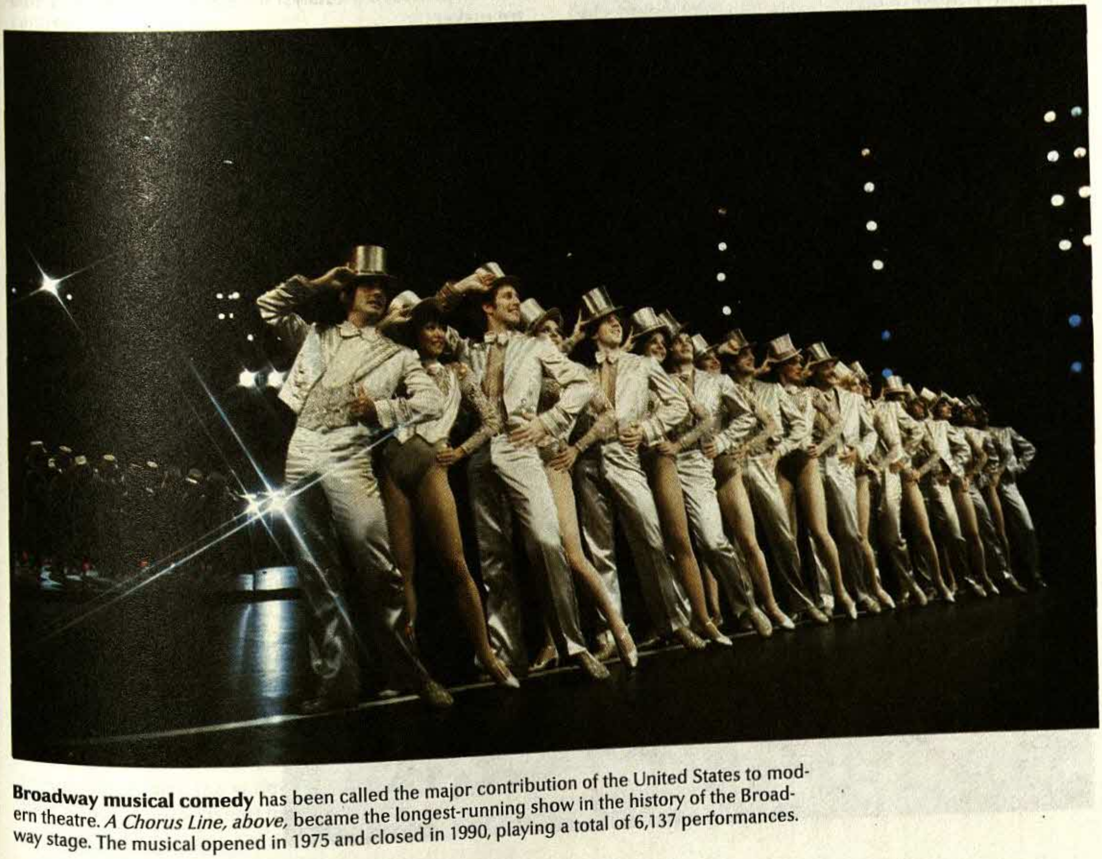
Canada. Theatre in French Canada can be traced from the work of Marc Lescarbot, a French immigrant who staged his first production in 1606. Theatrical productions in English did not begin until the mid-1700's. During the 1900's, important landmarks in Canadian theatre were the founding of Le Théâtre du Nouveau Monde in 1951 and the Stratford Shakespearean Festival at Stratford, Ontario, in 1953. The formation of the Manitoba Theatre Centre in 1958 began a regional theatre movement that established a chain of theatres across the country. The Centre d'Essai des Auteurs Dramatiques (the Dramatists' Centre) and its successor the Association Quebecoise du Jeune Théâtre (the Association of Young Theatre) set up a vigorous alternative theatre movement in Canada. The National Theatre School was founded in 1960 and is *bilingual* (using or involving two languages). It teaches in Canada's two official languages, French and English. The school remains Canada's chief centre of theatre training.

United States. Major centres of professional theatre in the United States are New York City, Chicago, and Los Angeles. The theatres on and near Broadway have long been the most important driving force in U.S. drama as well as musical comedy. But the increasing expense of staging a Broadway production has narrowed the range of plays offered there. Producers limit themselves almost entirely to shows that indicate promise of success or that have been successful elsewhere. A play must be a big box-office hit to survive long on Broadway. Many productions close after only a few performances with great financial losses. Others run for years, especially large, spectacular musicals.

In the 1950's, *off-Broadway theatre* developed in New York City from dissatisfaction with the "hit" or "flop" pattern of Broadway productions. The purpose of off-Broadway theatre was to offer an alternative, more experimental theatre and to present plays of greater artistic quality. Most off-Broadway theatres were originally located in low-rent areas. Most had poorly equipped stages, limited seating, and few conveniences for the audience. The originality of the script, the creativeness of the performers, and the low cost of production made up for such disadvantages.

By the 1960's, however, costs had begun to rise, and off-Broadway theatre was too often being used to test commercial possibilities. So the more enterprising theatrical producers began staging performances in shopfront theatres and lofts. This movement became known as *off-off-Broadway* and, since the mid-1960's, has become a major force in experimental drama. However, off-off-Broadway too is beginning to reflect commercial values and standards.

The Mark Taper Forum in Los Angeles became noted for its productions of new works. *Stand-Up Tragedy, above,* deals with poor minority boys in a New York City school.



Broadway musical comedy has been called the major contribution of the United States to modern theatre. *A Chorus Line, above,* became the longest-running show in the history of the Broadway stage. The musical opened in 1975 and closed in 1990, playing a total of 6,137 performances.

The Arena Stage in Washington, D.C., is one of the leading regional theatres in the Eastern United States. The theatre was founded in 1950 and presents both new plays and revivals of such classics as *The Cherry Orchard, left,* by the Russian dramatist Anton Chekhov.

Theatre outside New York City has begun to depend less and less on Broadway. From the 1960's onward, nonprofit resident theatres have increased in number and reputation throughout the United States. The Goodman Theatre in Chicago, The Mark Taper Forum in Los Angeles, and the Long Wharf Theatre in New Haven, Connecticut, are prominent examples. In addition, many colleges and universities have theatres organized administratively like resident professional companies. There are also more than 5,000 community theatres in the United States, providing entertainment to local audiences and an outlet for the creative talents of their members. Many community theatres employ a full-time director who supervises all productions. Many of these theatres are run exclusively by volunteers. Others pay the director of each production and also fund the fees of the designer and the chief technician.

Latin America. Mexico has the longest sustained tradition of theatre in Latin America. In the 1900's, there have been two periods of vibrant and innovative theatrical activity. From 1928 to 1947, the influence of groups such as the Teatro de Ulises (the Ulysses Theatre) and the Teatro de Orientación (the Orientation Theatre) stimulated experimental work. Then, in the 1960's and 1970's, the activities of the playwright and director Emilio Carballido provided a catalyst for a new generation of theatre makers.

Brazilian theatre stands out amid the complex and important traditions to be found in South America. The range and quality of its theatre is outstanding. The most important cities for drama are Rio de Janeiro and São Paulo, but this has not prevented the growth of theatre in other parts of Brazil. In the northeast, African cultural traditions provide a strong influence. Nevertheless, the

The Steppenwolf Theatre led an explosion of regional theatre activity in Chicago beginning in the 1970's. The Steppenwolf company gained recognition for its powerful productions of such modern dramas as *Orphans, left.*

An actor performing in Japanese Noh theatre, *left,* wears traditional robes and a mask to represent his character and uses slow, stylized movements to convey emotion.

Zoë Dominic

work of such companies as Os Comediantes (the Comedians), Teatro Brasileiro de Comedia (the Brazilian Theatre of Comedy), Teatro Arena, and Grupo Macunaima have established Rio and São Paulo as major theatrical centres.

Asia. The countries of Asia boast some of the most ancient theatrical traditions in the world. This is particularly true in China and India.

Live theatre also has an important place throughout Southeast Asia. Puppetry and masked dance-dramas are common forms of traditional theatre. Urban popular drama and spoken drama are more modern manifestations where dialogue takes precedence over dance. In recent years, the competition from Western music and from television and film has begun to threaten the popularity of the work of both traditional and modern theatre groups. Yet in the Philippines, Indonesia, Malaysia, and Singapore, theatre remains a dynamic and vital social art. See **Wayang.**

China. Theatre in China has a long and varied history. A host of regional forms, involving song, music, dance, and acrobatics, have been recorded as part of the Chinese theatrical tradition. Over 360 different regional styles are said to exist throughout the country.

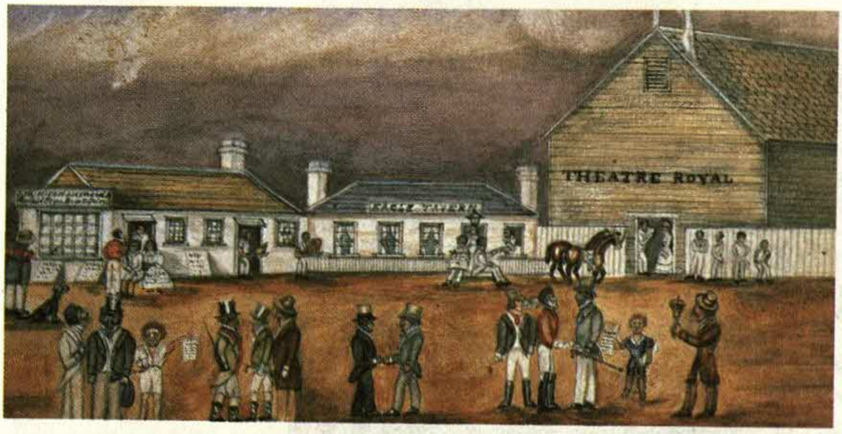
The emergence of Yuan theatre in the 1200's established conventions for theatre practice that were subsequently refined into sophisticated urban traditions such as Kungu and Beijing opera. Western-style plays, involving spoken dialogue, began to receive performances in 1907. After 1949, the Chinese Communist Party sought to determine both the practice and substance of traditional theatre. During the Cultural Revolution of 1966-1969, Beijing opera was banned. By 1977, however, the performance of traditional music-dramas was officially back in favour. Since then, the variety and vigour of Chinese theatre has re-established itself.

India. India also has ancient theatre traditions. Elaborate conventions for the building of theatres, the structuring of plays, and the codifications of gestures, vocal delivery, and dance are recorded in the *Natyashastra,* a Sanskrit handbook on theatre practice written in the A.D. 200's. Modern theatre, however, owes more to western European influences than to indigenous traditions. Since the mid-1880's, Indian playwrights have sought to combine Indian and Western influences.

Many state capitals stage performances of modern plays in English or in one of India's many regional languages. However, amateur companies far outnumber commercial theatres. There are over 3,000 registered amateur companies in just Calcutta. Many of the actors helping to make up these amateur groups are semiprofessionals who work in films, television, or advertising when they are not performing with their group.

Japan. In Japan, both classical and modern traditions of theatre draw large audiences. *Noh* theatre, a refined and poetic mask-drama, and *Kabuki,* a form of popular theatre that uses spectacular sets, are among the best-known of classical forms. Meanwhile, the major movements in modern theatre are *Shingeki* and *post-Shingeki.* Shingeki ("new theatre"), emphasizes the primacy of the text and is rooted in a proscenium style of staging. Post-Shingeki, an experimental form of theatre, depends on the creativity of the actor and exploits both open and found spaces.

Australasia. Every state capital in Australia has its own theatre company. These are the Sydney Theatre Company, which appears at the Sydney Opera House; the Melbourne Theatre Company; the South Australian Theatre, located in Adelaide; the Queensland Theatre Company, in Brisbane; the National Theatre Company, at the Playhouse, in Perth, and the Tasmanian Theatre Company in Hobart. Numerous smaller theatres—such as La Boite in Brisbane, the Hole in the Wall in Perth, and the Griffin Theatre in Sydney—have staged new



One of Australia's first professional theatres was the Theatre Royal in Melbourne. W. F. E. Liardet painted this scene in 1842, the year after the theatre opened.

works by Australian playwrights. Aboriginal theatre, women's theatre, and youth theatre have flourished since the 1970's. The movement toward decentralization, evident during the 1980's, has led to the growth of community theatre groups concerned with local issues and grassroots involvement. Much of this highly varied theatrical activity is supported financially by the Theatre Board of the Australian Council.

Major theatres in New Zealand are the Mercury Theatre and Theatre Corporate, in Auckland; Centrepoint Theatre, in Palmerston North; Downstage Theatre and Circa Theatre, Wellington; the Court Theatre, in Christchurch; and Four Seasons Theatre, in Dunedin. Anamus Theatre, founded by Paul Maunder and others in 1971, is perhaps the best-known example of the *collectives* that are an important part of contemporary theatre-making in New Zealand. A collective is a cooperative enterprise in which members collaborate in preparing the entertainment, even the script. The Maori touring collective Maranga Mai ("Wake up") is another example of this strand of group-scripted theatre.

Europe. Tracing its descent from ancient Greece and Rome, theatre in Europe became a tool of religion in the Middle Ages. Groups of tradesmen called *guilds* staged plays on Biblical and moral subjects. However, a secular tradition survived, supported at festivals and fairs by wandering entertainers such as singers, jugglers, acrobats, and dancers.

During the Renaissance, the rediscovery of Roman playwrights such as Plautus, Terence, and Seneca awoke an interest in the theatre among members of the aristocracy and nobility. New plays were written and performed at royal courts, and new theatres were built according to plans described by classical Roman writers. The modern theatre came into existence in the 1500's. The theatrical tradition, as found in the individual countries of Europe, is the outcome of all these events but has also been shaped by national factors.

Ireland. The Abbey Theatre in Dublin, in the Republic of Ireland, has been the home of modern Irish drama since 1904. When the original theatre was burnt down in 1951, it was replaced by two auditoriums—the new 628-seat Abbey Theatre and the 167-seat Peacock Theatre. It has remained a writer's theatre and a focus of national culture throughout the 1900's. The Gate Theatre has long been another Dublin venue. More recently, groups such

The Perfectionist and other plays by Australian dramatist David Williamson proved extremely popular with local audiences in the 1980's.

The Royal Court Theatre in London produces new and exciting plays by contemporary writers, such as *Top Girls, above,* by Caryl Churchill.

England's Royal National Theatre is one of the leading theatre companies in the world. The National stages classics of world drama as well as premieres of new works, such as the drama on the left by the modern English playwright David Hare.

Royal National Theatre production of *The Secret Rapture*

as The Field Day Theatre Company, founded by the playwright Brian Friel, have further enriched Ireland's innovative and unique dramatic tradition.

United Kingdom. In the United Kingdom (UK), London is the theatrical centre with more than 40 West End commercial theatres and two major subsidized theatres—the Royal National Theatre and the Royal Shakespeare Company. The latter was formed out of the Shakespeare Memorial Theatre in 1961 and has its headquarters outside London at Stratford-upon-Avon, Warwickshire. In London, the company is based at the Barbican Centre. The Royal National Theatre, which has three auditoriums, is housed in a major arts complex on the South Bank of the River Thames. The Royal National Theatre was founded in 1963 and moved to its present site in 1976.

There are repertory and civic theatres throughout England, Wales, and Scotland. They had their heyday in the years between the end of World War II (1939-1945) and the 1980's, when *public subsidies* (government funds) helped many theatrical organizations to blossom and expand. The innovations and achievements in theatre from 1956 to 1981 and the remarkable growth in theatre-going in the United Kingdom during those years resulted from a policy of regional subsidy. With a rapid increase in the number of companies after 1968, and a constant lack of adequate financial support in the 1980's, many regional theatres in the late 1990's found themselves struggling to survive.

France. The Paris-based Comédie Française is the oldest state-supported national theatre in the world. Founded in 1690, it specializes in classical performances of plays by France's greatest writers. Other state-funded theatres include the Odéon, founded in Paris in 1781, and the Théâtre Nationale Populaire, founded there in 1920.

The Birmingham Repertory Theatre stands in Broad Street, Birmingham, in the English Midlands. The theatre has a reputation for enterprise and excellence in its drama productions.

Novosti from Sovfoto

The Maly Theatre is the oldest theatre in Moscow. It features traditional Russian plays and classics. *Serfs, left,* by Pyotr Gnedich, explores the lives of the Russian aristocracy during the 1800's.

The national theatres outside the French capital were established as part of the government's policy of decentralization. This policy of bringing French theatre to the people received considerable financial backing from two ministers of culture, André Malraux (1960-1969) and Jack Lang (1981-1986). The theatres that were set up under this system include ones at Caen, Marseille, Strasbourg, and Lyon. The state also supports other drama centres, including ones in the cities of Nice, Rennes, St.-Etienne, and Toulouse. The theatrical companies of many of these places also tour neighbouring communities. The growth of decentralized theatre in France during the second half of the 1900's has ensured that exciting and innovative theatre is available to audiences throughout the country.

Germany. Germany has one of the most extensive systems of state-supported theatres in the world. Almost every main city has its own ballet, opera, and drama companies, heavily supported by the city or state concerned. Many of these state- or city-supported theatres date back to the late 1700's. Within each city, all the theatres work under a single manager. The manager is appointed by the city or state and the theatres share a staff of directors and designers.

National Theatre of Norway

Theatre in Scandinavia features the works of the major playwrights of Denmark, Sweden, and Norway. The National Theatre of Norway has presented revivals of plays by Henrik Ibsen, Norway's greatest dramatist and a founder of modern drama in the Western world. This scene is from Ibsen's early fantasy, *Peer Gynt.*

Scandinavia. There are major subsidized theatres in each of the Scandinavian countries. In Sweden, the most notable are the Royal Dramatic Theatre in Stockholm and the city theatre of Malmö. However, nonsubsidized groups called free groups have grown in number since 1970. Major subsidized theatres in Norway include the Norske Teatret. In the 1970's, five regional subsidized theatres opened and about 20 independent groups founded the Theatre Centre.

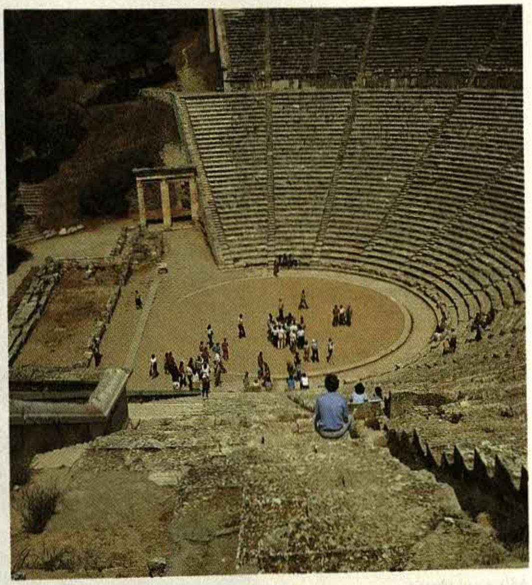
Most major theatres in Denmark are subsidized, including the Kongelige Teater and Folketeater in Copenhagen, and provincial theatres in Århus, Ålborg, and Odense. Odin Teatret is an influential experimental theatre in Denmark. Based in Holstebro, this international theatrical community was founded in 1964 by Eugenio Barba, an expatriate Italian.

Russia. Moscow and St. Petersburg are the two major theatre centres in Russia. The Moscow Art Theatre, founded in 1898, is perhaps the most respected theatre in Russia. The Maly Theatre, founded in 1824, is the city's oldest theatre. The Theatre of the Revolution was founded in 1922. It was renamed the Mayakovsky Theatre in 1954 in honour of Vladimir Mayakovsky, a Russian poet and playwright who died in 1930. Newer theatres in Moscow include the Taganka, founded in 1946, and the Sovremennik, founded in 1958. In St. Petersburg, the Alexandrinsky Theatre was opened in 1824 and later renamed the Pushkin Theatre in honour of Alexander Pushkin, Russia's greatest poet. The other major St. Petersburg theatre is the Gorki, founded in 1919 and named after Maxim Gorki, a modern Russian novelist and dramatist.

Italy. Italy is the home of the Commedia dell'Arte, one of the most influential developments in drama. Although the influence of Commedia is today of only historical importance, Italy itself is still a major force in European theatre. The establishment of *teatri stabili* (permanent companies) has been a significant development since 1947. Funded by city or provincial governments, these regional theatres have nurtured the creativity of major directors such as Luchino Visconti. Some resident companies, such as the Piccolo Teatro in Milan and the Teatro Stabile of Turin have gained national and international distinction. There is also a radical experimental tradition in contemporary Italian theatre.

Spain. After the Spanish Civil War (1936-1939) and World War II (1939-1945), Spanish theatre went through a long period of decline. However, the establishment in 1978 of the state-funded National Theatre Centre helped to boost theatrical quality. Independent companies such as the Cuadra de Sevilla have won international acclaim. Theatre festivals take place in Almagro, Mérida, and Santander.

Greece, which with ancient Rome was the cradle of the European theatre tradition, remains dominated by the classical plays written in the 400's B.C. Outdoor productions are staged in ancient theatres such as the Roman theatre of Herodes Atticus in Athens and the Hellenistic theatre at Epidaurus, in southern Greece. The open-air theatre at Epidaurus holds over 14,000 spectators.



Epidaurus is the site of a famous open-air ancient Greek theatre. It was built during the 200's B.C. on the Peloponnesus, a peninsula of southern Greece.

The Greek National Theatre, founded in 1932, and the Art Theatre, established in 1942 by director Karolos Koun, have staged notable productions of the ancient tragedies and comedies. The most popular forms of modern theatre are farces and revues, although the achievements of such playwrights as Pantelis Prevelakis bear eloquent witness to the seriousness of contemporary Greek drama.

For a history of the theatre, see **Drama,** with its list of related articles.

Related articles in ***World Book*** include:

Actors and entertainers

Aldridge, Ira
Alleyn, Edward
Anderson, Dame Judith
Ashcroft, Dame Peggy
Barrault, Jean-Louis
Barrymore (family)
Bernhardt, Sarah
Boucicault, Dion
Brando, Marlon
Braithwaite, Dame Lilian
Brice, Fanny
Burton, Richard
Campbell, Mrs. Patrick
Cilento (Diane)
Cohan, George M.
Coward, Sir Noel
Dietrich, Marlene
Duse, Eleonora
Evans, Dame Edith
Finney, Albert
Fonda, Jane
Fontanne, Lynn
Garrick, David
Gielgud, Sir John
Gish, Dorothy
Gish, Lillian
Guinness, Sir Alec
Gwyn, Nell
Hayes, Helen
Hoffman, Dustin
Humphries, Barry
Kean, Edmund
Langtry, Lillie
Laughton, Charles
Lillie, Beatrice
Lindsay, Howard
Lloyd, Marie
Lunt, Alfred
MacLiammóir, Micheál
Macready, William
McKenna, Siobhán
Olivier, Laurence
O'Toole, Peter
Plowright, Joan
Redgrave (family)
Richardson, Sir Ralph
Robeson, Paul
Robey, Sir George
Robson, Dame Flora
Rogers, Will
Roscius, Quintus
Scofield, Paul
Siddons, Sarah K.
Terry, Dame Ellen
Thespis
Thorndike, Dame Sybil
Tilley, Vesta
Ustinov, Sir Peter
Waters, Ethel
Welles, Orson
Williams, Emlyn
Wolfit, Sir Donald

Directors, producers, and designers

Baylis, Lilian Mary
Brook, Peter
Burbage (family)
Casson, Sir Lewis
Cochran, Sir Charles Blake
D'Oyly Carte, Richard
Edwards, Hilton
Granville-Barker, Harley
Guthrie, Sir Tyrone
Hall, Sir Peter
Horniman, Annie
Irving, Sir Henry
Kemble (family)
Littlewood, Joan
Marsh, Dame Ngaio
Martin-Harvey, Sir John
Miles, Lord
Nichols, Mike
Reinhardt, Max
Robinson, Lennox
Stanislavski, Konstantin
Tree, Sir Herbert Beerbohm
Ziegfeld, Florenz

Other related articles

Abbey Theatre
Ballet
Burlesque
Dancing
Drama
Europe (picture: Ancient Greek drama)
Film industry
Globe Theatre
Mime
Minstrel show
Moscow Art Theatre
Mummers
Music hall
Musical comedy
Old Vic
Opera
Operetta
Puppet
Shadow play
Shakespeare, William (The Elizabethan theatre)
Vaudeville
Wayang

Outline

I. Modern theatre architecture
  A. The auditorium
  B. The stage
  C. The behind-the-scenes spaces
II. The producer
  A. Acquiring a script
  B. Raising money
  C. Obtaining a theatre
  D. Assembling a creative team
  E. Keeping financial records
III. The director
  A. Interpreting the script
  B. Working with the designers
  C. Casting
  D. Rehearsing
  E. The director's assistants
IV. The performers
  A. Body and voice
  B. Observation and imagination
  C. Concentration
  D. Systems of acting
  E. Creating a role
V. Set design
  A. The set designer
  B. Kinds of scenery
  C. Changing scenery
  D. Properties and set dressing
VI. Lighting and sound
  A. Lighting methods
  B. Sound production
VII. Costumes and makeup
  A. Costume design
  B. Makeup techniques
VIII. Theatre around the world
  A. Africa
  B. America
  C. Asia
  D. Australasia
  E. Europe

Questions

What is a *flat*? a *scrim*? a *cyclorama*?
What are the two chief systems of acting?
What is the difference between a proscenium stage and a theatre-in-the-round?
How can costumes help an audience understand a play?
What kinds of sound can be used in a play?
What is the difference between Broadway, off-Broadway, and off-off-Broadway?
What does the director need to know about a play?
What is the difference between *theatre* and *drama?*
What is the oldest national theatre still operating?
What is a stage picture?

Thebes is the Greek name of a city in ancient Egypt that served as a capital for many Egyptian kings. Thebes stood near the Nile River, at the site of what is now the city of Luxor (see **Egypt, Ancient** [map]).

Thebes was a village of little importance until a Theban prince of the Eleventh Dynasty became king of Egypt in 2052 B.C. A *dynasty* is a series of rulers in the same family. Theban kings expanded Egypt's empire to its greatest extent during the Eighteenth Dynasty, which ruled from 1554 to 1304 B.C. The Theban god Amon-Re became the most important god in Egypt. Later, kings of the Nineteenth and Twentieth Dynasties, who were not from Thebes, built tombs and temples in and near the city. The Romans destroyed Thebes in 29 B.C.

Theban temples still stand at Karnak and Luxor. The ruins of funeral temples of Egyptian kings and queens are across the Nile from Luxor. Tombs lie in cliffs along the river, in the so-called Valley of the Kings (see **Valley of the Kings**).

Thebes was an ancient city in Boeotia, a region in central Greece. At one time, it was the most powerful city-state in Greece, and the head of the confederacy of cities known as the Boeotian League. The city lay in the southeastern part of Boeotia, about 48 kilometres north of Athens (see **Greece, Ancient** [map]). According to ancient legends, Cadmus, a prince of Phoenicia, founded Thebes. The city appears in the Oedipus legends, which are almost as famous as the stories of Troy (see **Oedipus**).

The historical record of Thebes begins about 500 B.C., when the people of Thebes and of Plataea, another ancient Greek city, began to quarrel. Later, Thebes helped the Persians in their invasion of Greece in 480 B.C. Thebes fought frequent wars with Athens. The most important of these was the Peloponnesian War, which began in 431 B.C. After this war, the Boeotian League fell to pieces under the tyrannical rule of Sparta. It became important again between 379 and 374 B.C. through the patriotic efforts of Pelopidas. In 371 B.C. the Thebans, led by Epaminondas, won a victory over the Spartans at Leuctra, and thus gained control over Greece.

When Epaminondas died in 362 B.C., Theban control of Greece came to an end. The exhausted Greek states came under the rule of Philip of Macedon and his ambitious son, Alexander the Great. The Thebans revolted against Alexander, and he punished them by destroying their city. Thebes was rebuilt in 316 B.C., and was important under the later Roman Empire. The city flourished as a centre of the silk trade during the A.D. 1000's and 1100's. Thebes began to decline when the Turks gained control of the city. The town of Thivai now stands on the site of Thebes.

See also **Cadmus; Pelopidas; Pindar.**

Theiler is the family name of two South African scientists, a father and son, who gained international fame.

Thebes was a city in ancient Egypt. The Theban temple, *left,* still stands at the city of Luxor on the Nile River.

Sir Arnold Theiler (1867-1936) was a veterinary research scientist. Onderstepoort in South Africa, where Theiler established his laboratory, now has an international reputation for veterinary science. It honours Sir Arnold Theiler as its founder.

Arnold Theiler was born at Frick, in Switzerland. He set up a private practice in South Africa in 1891. A terrible rinderpest plague of 1896, which wiped out half the country's cattle, spurred his research into obscure cattle diseases.

During the second Anglo-Boer War (1899-1902), Theiler served the Boers as a veterinary surgeon. When the British captured Pretoria, they allowed him to continue his research. He gained his doctorate in 1901, and seven years later set up his laboratory in Onderstepoort. In 1910, he was appointed director of veterinary services for the Union of South Africa. He was knighted in 1914 for his work. It included pioneer research into the tsetse fly, and how it spread sleeping sickness. He also carried out research on the effects of poisonous plants on animals, various animal diseases, pests, and animal diets.

Max Theiler (1899-1972), a son of Sir Arnold, became South Africa's first Nobel Prize winner in 1951. He received the prize for his work with yellow fever. He was born in Pretoria.

Theine, another name for caffeine. See **Caffeine.**

Theism is belief in a god or gods. The term comes from the Greek word *theos,* meaning *god.* Theism plays an important role in most religions, but various faiths differ in their teachings about a god or gods. The followers of ancient Greek and Roman religions were *polytheistic*—that is, they worshipped more than one god. Today, the followers of most major religions are *monotheistic.* They accept only one god.

The words *theism* and *theistic* are used principally in discussing religions that have one god. Such religions include Christianity, Islam, Judaism, and some forms of Hinduism. These faiths stress the existence of an all-knowing, all-powerful god. This god may provide certain ways of life for people to follow and may offer them salvation.

Theism is also a type of philosophical belief. It supports the existence of a god, as opposed to *atheism,* which argues that no god exists. Theism also states that a god exists apart from the world. This concept differs from *pantheism,* the belief that a god exists in all forces of nature and the universe.

See also **Atheism; Deism; God; Polytheism; Religion** (Belief in a deity).

Theme park is an outdoor entertainment centre that offers rides, games, exhibitions, and shows based on one or more special ideas, or themes. The use of themes is the main difference between a theme park and a traditional amusement park. An amusement park offers a selection of different entertainments, such as roller-coaster rides, ferris wheels, merry-go-rounds, and side-shows including coconut shies and shooting galleries. A theme park offers entertainments that are related to each other by a common idea such as wildlife, space travel, or how people lived at some time in the past. In an amusement park, customers must pay for each game, ride, or other entertainment separately. In a theme park, customers usually make a single payment to enter and have all their entertainments free.

The first theme parks opened in the United States, soon after World War II. Disneyland, the oldest theme park in the world, opened in 1955 at Anaheim in California. It was divided into several different "lands" based on scenes from well-known films produced by the Walt Disney film company (see **Disney, Walt**). In 1971, the company opened Walt Disney World, near Orlando, Florida. Near this theme park is the futuristic EPCOT

Disney theme parks, like Walt Disney World, *above,* attract millions of visitors annually. They feature exhibits, rides, and shows partly based on films by Walt Disney Productions.

Center, situated on Lake Buena Vista. The world EPCOT stands for Experimental Prototype Community of Tomorrow. It was opened in 1982. In 1983, the Walt Disney organization opened the Tokyo Disneyland, the first Disney theme park outside the United States. Euro Disneyland, the first Disney theme park in Europe, at Marne-la-Vallée, near Paris, France, was built to open in 1992. It is part of a vast leisure complex one-fifth of the area of Paris. The original Disneyland provided a model for later theme parks throughout the United States. Many are devoted to single themes, such as Astroworld, at Houston, Texas. Others have themes related to the United States culture and way of life, such as the Great America theme park at Santa Clara, California.

Theme parks gradually spread to other countries in the late 1900's. During the 1980's, many theme parks opened in the United Kingdom. Theme parks also opened in Australia. There are now hundreds of theme parks all over the world.

Attractions at theme parks. Theme parks, which are generally owned by private companies, offer a very wide range of entertainments to visitors. Parks based on historical themes often have museum-like exhibitions. For example, Flambards, at Helston in Cornwall, England, has an authentic life-size Victorian village with real shops, a World War II city street with all the atmosphere of an air raid, and an aeropark with helicopters and aeroplanes on display. At Bendigo and Ballarat, both in the Australian state of Victoria, visitors can wander through the streets of gold rush towns of the 1850's and take an underground trip through a gold mine.

Parks with a fantasy theme may have live shows. For example, the Magical Kingdom of Camelot theme park, near Chorley in Lancashire, England, is a park based on the medieval world of King Arthur's court. Its attractions include Merlin's Magic Show, falconry displays, and recitals of medieval music. Some theme parks may also have animal attractions. Sea World, at Southport in Queensland, Australia, has among its many attractions a marine life show featuring dolphins and sealions.

Rides and slides. All theme parks provide rides, waltzers, dodgem cars, slides, and water-based entertainments. But the rides and slides reflect the themes of the parks. For example, at Fantasy World, one of the five thematic sections of Alton Towers, Britain's top theme park, in Staffordshire, England, visitors can spiral through total darkness on a ride called the Black Hole. Children also enjoy playing in swimming pools and being swept down narrow water slides. At Alton Towers's Aqualand, they can enjoy many water-based thrills. Sea World, in Queensland, Australia, has a free-fall water slide.

The most exciting and scary rides are known as *white knuckle rides.* The Benbom Brothers Dreamland White Knuckle theme park, at Margate, Kent, England, specializes in white knuckle rides. For example, the Looping Star roller-coaster turns its passengers upside down as it whirls them through a full circle.

Much of the money spent on theme parks is used to ensure that rides are safe. Companies running theme parks must take every precaution to make sure that people cannot fall out of their seats or catch their hair or clothing in the machinery of a ride. Theme park organizers will close a ride temporarily if their safety checks reveal a fault. The organizers may impose rules on visitors using the rides. For safety reasons it is important to follow these rules.

Themistocles (514?-449? B.C.) was an Athenian statesman and soldier in the Persian Wars. He saved Greece by his statesmanship and laid the base for Athens' greatness with his naval policy.

Little is known of Themistocles' early life. He began his political career in 490 B.C. after the Battle of Marathon and the retreat of the Persians. Themistocles opposed Aristides, who was then leader of Athens. In 482 B.C., he defeated Aristides in a dispute about what was to be done with the silver from the mines at Laurium. Themistocles had always favoured naval expansion, and proposed that Athens increase its fleet. Aristides was banished for opposing this plan, and Themistocles became the political leader of Athens.

Themistocles was certain that the Persians would attack again, but that this time the battle would be decided on the sea. Two years later the Persians returned. In a battle at Thermopylae, they overwhelmed a force of about 1,400 Greeks, led by the Spartans under Leonidas. Themistocles then moved the Athenians to Salamis, where he engaged the Persians in battle. He destroyed the Persian fleet and forced the Persians to leave Athens. The following year the allied Greeks completely defeated the Persians at Plataea.

Themistocles was ambitious and enjoyed taking chances. But many Athenians thought he was arrogant. Eventually, they became convinced that he was involved in disloyal dealings with foreign states. His political enemies persuaded the people of Athens to exile him around 471 B.C. Themistocles spent his last years in Persia, where the Persian king awarded him an estate.

See also **Aristides; Greece, Ancient** (The Persian Wars); **Salamis.**

Theocracy is a form of government in which the state is ruled by a priest or priests, and in which members of the priesthood have authority in civil and religious matters. The word *theocracy* comes from two Greek words, *theos,* which means *God,* and *kratein,* which means *to rule.*

Many ancient peoples believed that their god or gods had handed down laws for their government. The Code of Hammurabi was supposed to have been divinely revealed. The most famous theocracy was that of the Israelites, to whom God gave the Law through Moses.

In the 1600's, the Puritan government of Massachusetts, New England, was called a theocracy. It was conducted for many years on the principle of obedience to divine law, as interpreted by the clergy.

Theocritus (200's B.C.) was a Greek poet who established the character of Greek pastoral poetry. Pastoral poetry deals with rural themes. Theocritus set the standard for pastoral poetry with his choice of themes, their lively presentation, and their emotional impact.

Thirty complete short poems attributed to Theocritus exist today. Many of these poems, called *idylls,* re-create conversations or singing contests among herders about such subjects as unreturned love, magic, and epic heroes. Theocritus presented these poems in the form of dialogues, hymns, and short narratives (see **Idyll**). His influence can be seen especially in the *Eclogues* by the Roman poet Virgil.

Theocritus was probably born in Sicily. His search for a patron took him to Alexandria, Egypt. The library there made the city a centre of literary activity. Theocritus perfected his writing under the influence of the Alexandrian librarian and poet Callimachus, an advocate of the short, highly polished poem.

See also **Greek literature** (The Hellenistic Age).

Theodolite is an instrument surveyors use to measure angles and directions. It is similar to the less commonly used transit. A theodolite gives more precise readings than does a transit. Some theodolites permit measurements to closer than one *second of arc* (a subdivision of a degree defined as $\frac{1}{3600}$ of a degree). Most theodolites are mounted on a *tripod* (three-legged stand). A theodolite has a telescope that permits accurate sighting in any direction. A horizontal plate below the telescope provides readings around the horizon in degrees, minutes, and seconds of arc. A vertical plate and scale, mounted to the left of the telescope, permit vertical readings.

Theodora (A.D. 502?-548) was the wife of Justinian I, Byzantine (East Roman) emperor from 527 to 565. A beautiful and strong-willed woman, Theodora tried to influence Justinian's policies and to use her position to advance her friends and ruin her enemies. In 532, a rebellion in the capital city of Constantinople (now Istanbul, Turkey) threatened to overthrow the empire. Theodora persuaded Justinian to stay and defend the city rather than to flee. Justinian crushed the rebels, thus securing his absolute power.

Theodora was probably born on Cyprus, to a poor family. She became an actress before marrying Justinian in 522, and was accused of having a part in numerous scandals, but many of the claims have been disproved. She founded homes for the care of poor girls.

See also **Justinian I.**

E. G. Theodore

Theodore, E. G. (1884-1950), played a prominent part in Australian politics in the early 1900's. He was premier and treasurer of Queensland from 1919 to 1925. He became a member of the House of Representatives in 1927, and federal treasurer in 1929.

At the beginning of the depression, Theodore urged the government to circulate more money, give more credit, and devalue the Australian pound on the international market. His scheme became known as *Theodore's Plan.* However, most politicians refused to support him. Theodore lost his seat in 1931 and later became a businessman. He was born in Adelaide, South Australia, and named Edward Granville Theodore.

Theodoric (A.D. 455?-526) was an *Ostrogoth* (East Goth) king who governed what is now Italy from A.D. 493 until his death. He won control of Italy from the barbarians who had taken it from the Romans 17 years earlier. Although a barbarian himself, Theodoric maintained a Roman form of government and Roman law in Italy. His rule was enlightened, peaceful, and just, and he won the praise of both barbarians and Romans. Theodoric let Romans hold high public office, and respected the senatorial class. He employed such prominent Romans as Boethius and Cassiodorus as his advisers and ministers of state. Theodoric believed in the Arian heresy, which denied the divinity of Christ. But he permitted his subjects to practise orthodox Christianity.

Theodoric was born in Pannonia, which included parts of what are now Austria, Hungary, and Slovenia. He spent several years in Constantinople (now Istanbul, Turkey). Constantinople was the capital of the Byzantine (East Roman) Empire. When his father, Ostrogoth king Theodemir, died in 471, Theodoric became king.

Theodoric alternately found himself an ally, then an enemy of the Byzantine emperors. He was a victim of a Byzantine plan to weaken barbarians by encouraging rivalries between them and then shifting support from one side to the other. In 488, Byzantine emperor Zeno commissioned Theodoric to attack Odoacer, the barbarian king of Italy. Theodoric invaded Italy in 489 and took control of most of the country in 490. He finally defeated Odoacer at Ravenna in 493, then murdered him. Germanic peoples remembered Theodoric in their legends as the heroic Dietrich of Bern.

Theodosius I (A.D. 346-395) was the Roman emperor who prohibited all *pagan* (non-Christian) practices in the Roman Empire. For this, he became known to Christians as *The Great.* However, he was a shortsighted ruler who weakened the empire by creating many new government jobs and by raising taxes. His will divided the empire between his sons Honorius and Arcadius, splitting it permanently into eastern and western empires.

Theodosius was born in Spain. He became a distinguished soldier. In 379, Emperor Gratian made Theodosius co-emperor, responsible for the eastern provinces. The Visigoths had defeated a Roman army in the east in

378. In 382, a treaty between Theodosius and the Visigoths made the Visigoths the first independent barbarian nation within the Roman Empire.

Theodosius became senior co-emperor when Gratian died in 383. Gratian's brother, Valentinian II, became emperor of the western provinces. Valentinian died in 392, and pagans gained control of the western provinces. Theodosius crushed the pagans in 394 and ruled the entire empire until he died.

Theology is the study and description of God. It may also be the expression of religious belief. The word *theology* comes from the Greek words *theos* (god) and *logos* (talk). Theology explores a wide range of questions, such as: "Does God exist? What is the nature of God? What is God's relation to the world and to its inhabitants? and How do human beings know or experience God?" Some branches of theology deal with the history of religion or the study of sacred writings. Other branches deal with the defence of religious doctrines against opposing views or the application of doctrine to daily life.

Approaches to theology differ from one religion to another. They also vary within a religious tradition. For example, some Christian theologians base their understanding of God on such authoritative sources as the Bible and the decrees of church councils. Others explain their understanding of God in terms of philosophy, psychology, or science. In most cases, a theologian's own religious experience plays an important part in his or her theological system.

See also **God; Religion.**

Theorem. See **Geometry; Binomial theorem; Pythagoras' Theorem.**

Theosophy is a system of philosophic and religious thought. Theosophy is based on claims of a mystic insight into the nature of God and the laws of the universe. The theosophist believes that the truest knowledge comes not through reason or the senses, but through a direct communion of the soul with divine reality.

The term theosophy has been applied specifically to the beliefs and teachings of the Theosophical Society. This society was founded in the United States in 1875 by Madame Elena Petrovna Blavatsky and others. Hindu and Buddhist thought and doctrines have become prominent in theosophy. A characteristic feature is the belief in reincarnation, in accordance with the Hindu doctrine of Karma. This doctrine states that the spirit advances to its goal through a succession of earthly lives, and that the consequences of a person's actions in the present life are reaped by his or her successor on earth in a fresh incarnation.

See also **Besant, Annie Wood.**

Theotokopoulos, Domenikos. See **Greco, El.**

Therapy. See **Chemotherapy; Drug; Occupational therapy; Physiotherapy; Psychotherapy.**

Theravada. See **Buddhism** (Buddhist schools).

Theremin is a boxlike musical instrument that resembles a radio receiver. Musical tones are produced by two high-frequency electronic circuits inside the instrument. A player creates music by moving the right hand through the air in front of an antenna projecting from the instrument. The player controls the volume by means of a switch and by moving the left hand over a metal loop on the theremin. The Russian scientist Lev Theremin invented the instrument and first played it in public in 1920. The theremin is mainly a musical curiosity, but it has been used as a solo instrument. Composers of music for the theremin include Bohuslav Martinů and Edgard Varèse.

Theresa, Saint. See **Teresa, Saint.**

Thermal inversion. See **Air pollution** (Chief sources of air pollution); **Smog.**

Thermal pollution occurs when hot wastewater is discharged into rivers, lakes, seas, or other bodies of water. The wastewater raises the temperature of the body of water above its normal level and can harm animals and plants living in the water. For example, warmer water may interfere with fish growth, reproduction, and food supply. In some cases, fish may be killed due to the sudden and rapid rise in temperature resulting from the discharge of hot wastewater.

The major sources of thermal pollution are factories and power plants that use water to cool equipment or heat it to produce steam. Many countries issue regulations controlling the wastewater discharged by these facilities. Many factories and power stations attempt to reduce thermal pollution by cooling wastewater in cooling towers before releasing it, thereby allowing heat to escape into the air. Industries can also reduce thermal pollution by releasing hot water in scattered areas in order to prevent a dangerous temperature rise in any one place.

See also **Environmental pollution** (Water pollution; diagram).

Thermal springs. See **Hot springs.**

Thermocouple is an electric device that changes heat into electricity or electricity into heat. A thermocouple is made by twisting the ends of two different kinds of wire, such as iron and copper, together to form a *junction.* The opposite ends are also twisted together to form another junction. If one junction is heated, an ammeter connected to one of the wires between the junctions will show a *thermoelectric* (heat-generated) current flowing. The German physicist T. J. Seebeck discovered this effect in 1821. If a battery instead of an ammeter is connected to the thermocouple, one junction will become hot and the other will become cool. This effect was first noticed by the French physicist J. C. A. Peltier in 1834.

Thermocouples are used as thermometers and to generate electricity. Refrigeration devices have been made using them. In a thermocouple used as a thermometer, one of the junctions senses the temperature being measured, and the other is kept at a constant temperature. A voltmeter measures the voltage between the junctions and shows the temperature.

Thermodynamics is the study of various forms of energy, such as heat and work, and of the conversion of energy from one form into another. Engineers, chemists, and physicists use the principles of thermodynamics in understanding events in nature and in such activities as designing machines and calculating the loss or gain of energy in chemical reactions.

Thermodynamics is based chiefly on two *laws* (principles). The first law states that energy in a *system,* which may be anything from a simple object to a complex machine, cannot be created or destroyed. Instead, energy is either converted from one form into another or transferred from one system to another. For example, a *heat engine,* such as a gas turbine or a nuclear reactor, changes energy from fuel into heat energy. It then converts the heat energy into mechanical energy that can be used to do work. The total amount of energy always remains the same.

All systems also have internal energy that undergoes certain changes, but is never created or destroyed. Scientists study changes in this internal energy by measuring changes in such properties as the volume, temperature, and pressure of the system.

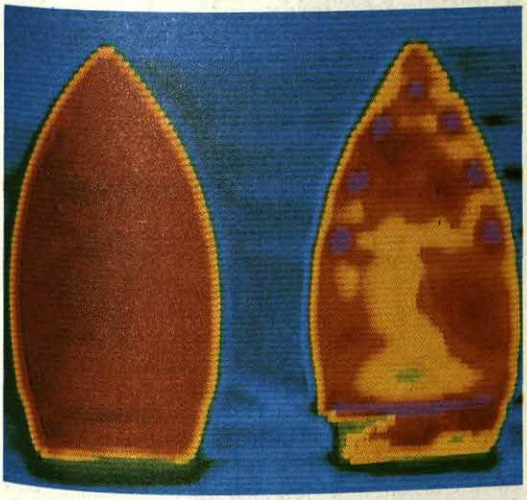
The second law of thermodynamics deals with the natural direction of energy processes. For example, according to this law, heat will, of its own accord, flow only from a hotter object to a colder object. The second law accounts for the fact that a heat engine can never be completely efficient—that is, it cannot convert all the heat energy from its fuel into mechanical energy. Instead, the engine transfers some of its heat energy to colder objects in the surroundings.

See also **Entropy; Heat** (Thermodynamics); **Clausius, Rudolf J. E.; Joule, James P.; Mayer, Julius R. von.**

Thermography is a detection technique that converts invisible heat energy into a visible picture. A device called a *thermograph* is used to produce a *thermogram* (heat picture). Thermography is used in industry, medicine, and many other fields.

A thermograph looks like a TV camera connected to a TV screen. It "sees" temperature by sensing heat energy, called *infrared energy.* Infrared energy is radiated naturally by all objects, and hotter objects radiate more than cooler ones. Inside a thermograph, a solid-state detector converts infrared energy into electrical signals. The signals are displayed as pictures on the TV-like screen. The pictures show different temperature ranges as variations of brightness or colour. These variations can be analysed by scientists.

Industrial uses of thermography include detecting overheated parts in electrical distribution systems and energy losses in manufacturing processes. The technique also is used to find leaks in the insulation of homes and other buildings. In addition, thermography provides a means of inspecting blast furnaces. A weak spot in a furnace wall is hotter than the surrounding areas, and so it appears lighter on a thermogram.



A thermogram of two irons shows the distribution of heat on their surfaces. The iron on the left has an even temperature. The iron on the right has hotter areas, which appear on the thermogram as light-orange, yellow, and purple.

In medicine, thermography can reveal arthritis, nerve damage, and blood circulation problems. Doctors also use thermography, along with other tests, to confirm the presence of breast tumours.

Military and police forces and firemen use thermography to see in the dark and through smoke. Pollution-control experts sometimes use the technique to determine the distribution of *thermal* (heat) pollution in bodies of water.

Thermometer is an instrument that measures the temperature of gases, liquids, and solids. The action of a thermometer is based on the fact that certain measurable physical characteristics of substances change when the temperature changes. These characteristics include the volume of a liquid and the length of a solid. Another is the *resistance*—that is, the opposition to the flow of electricity—in an electrical conductor.

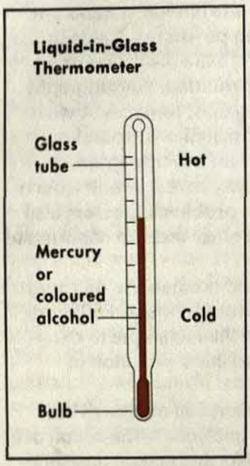
There are three principal types of thermometers: (1) liquid-in-glass, (2) deformation-type, and (3) electrical. Many types of thermometers are made as both *digital* thermometers and *disposable* thermometers.

Liquid-in-glass thermometers are the best-known type of thermometers. They include those used to determine the temperature in or outside a building, to measure the temperature of the body, and for cooking. Mercury is the most common liquid in these thermometers. Alcohol is used in areas where the temperature frequently drops below the freezing point of mercury −39° C. The liquid fills a glass bulb, which is connected to a sealed glass tube partially filled with liquid. When the temperature goes up, the volume of the liquid expands and the liquid rises. A temperature scale is on the outside of the thermometer.

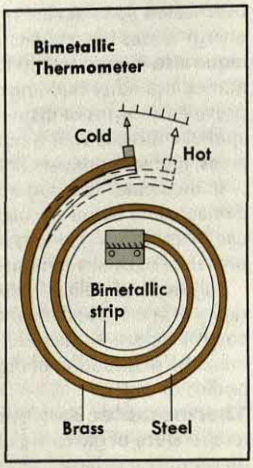
Deformation-type thermometers change shape as a result of an increase or decrease in temperature. There are two kinds of deformation thermometers, *bimetallic* and *Bourdon tube.* Bimetallic thermometers, the most common type, consist of two strips of different metals, such as iron and brass. The strips are fastened together from end to end, forming a bar. When the temperature rises, each metal expands at a different rate, which causes the bar to bend. This motion of the bar causes a pointer to move up or down a scale, indicating a temperature change. A type of bimetallic thermometer called a *thermograph* includes a pen that makes a written record of temperature changes.

Bourdon tube thermometers have a curved, flexible metal tube filled with a liquid, such as glycerol or xylene. A rise in temperature makes the liquid expand. The tube straightens out to accommodate the increased volume of liquid. A pen or pointer attached to the end of the tube indicates the temperature.

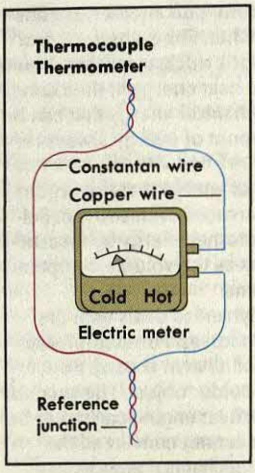
Electrical thermometers include *thermocouples* and *resistance thermometers.* Thermocouples, the most widely used type, consist of two wires of different metals. Both ends of the two wires are twisted together to form junctions. One of these junctions, called the *refer-*



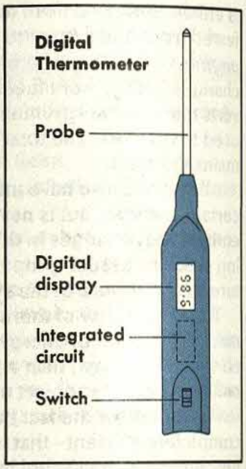
A column of liquid shows the temperature in a liquid-in-glass thermometer. The liquid in most such thermometers is mercury or coloured alcohol.



A bimetallic strip, consisting of two metals, can show temperature. As the temperature changes, the strip bends, indicating the temperature.



An electric voltage from a device called a *thermocouple* can be measured to show the temperature. An electric meter measures the voltage.



A digital thermometer has a circuit that changes electric temperature signals into numbers. The numbers appear in a display window.

ence junction, is kept at a constant temperature—usually 0° C. As the temperature of the other junction changes, a small voltage is generated between the two wires. The voltage is measured by an instrument called a *millivoltmeter,* which may have a temperature scale marked on it. Most thermocouples that measure the temperature of the air have wires made of copper and an alloy called *constantan.* Thermocouples with wires of other metals can measure temperatures up to 2800° C. See **Thermocouple.**

Resistance thermometers are made of such materials as copper, nickel, or platinum. A temperature change causes a variation in the *electrical resistance* of these metals (see **Electric circuit** [Circuit mathematics]). The variation is measured and expressed as a temperature value. Scientists use *platinum resistance thermometers* to check the accuracy of all other types of thermometers. Extremely reliable platinum resistance thermometers are used to measure temperatures from −259.35° C to 961.78° C on the *International Temperature Scale of 1990* (ITS-90). This scale provides a worldwide reference for temperature values.

Digital thermometers use electronic circuits and devices to show temperature measurements. These thermometers display the measurements as numbers. Digital thermometers measure temperature by means of a slender device called a *probe.* The probe is made of either a metal, such as copper or platinum, or a *semiconductor* (see **Semiconductor**). Temperature changes cause a large variation in the electrical resistance of these materials. Most semiconductors are more sensitive to temperature changes than are metals.

The probe is connected to an electronic circuit. The circuit receives temperature readings from the probe in the form of electrical signals. The signals are changed into numbers, which appear in a display window.

Disposable thermometers are sometimes used for measuring body temperature. They are cheaper than ordinary thermometers to manufacture and to buy. Most disposable thermometers lose their accuracy after a single use, but a few have been designed for repeated use.

Some disposable thermometers are made of materials that melt at certain temperatures. Others use substances called *liquid crystals,* which change appearance at specific temperatures (see **Liquid crystal**).

Temperature scales. Some manufacturers produce thermometers with a temperature scale in *Fahrenheit.* Most manufacturers produce thermometers with the Celsius scale. Some thermometers, especially in the United States, feature the Fahrenheit scale, although thermometers with both the Celsius and the Fahrenheit scale also exist. Most scientific thermometers use the Kelvin scale.

On the Celsius scale, water freezes at 0° C and boils at 100° C. The Kelvin scale is used for scientific measurement. On this scale, water freezes at 273 K and boils at 373 K. On the Fahrenheit scale, 32° F. is the freezing point of water and 212° F. is the boiling point. See **Weights and measures** (Temperature).

All temperature scales are now based on the International Temperature Scale of 1990. On this scale, temperature is determined by means of a series of fixed points called *equilibrium states,* which have assigned values. Temperatures are expressed in Celsius and Kelvin units, but may be converted to other scales.

History. The first known thermometer was invented in 1593 by the Italian astronomer Galileo. It was called a *thermoscope* and had only fair accuracy. An accurate thermometer using alcohol was developed in 1641. In 1714, Gabriel D. Fahrenheit, a German physicist, built a mercury thermometer of the type used today.

See also **Bolometer; Pyrometry; Temperature.**

Thermonuclear reaction. See Nuclear energy (Nuclear fusion); **Sun** (How long will the sun shine?; How the sun produces energy).

Thermoplastic materials. See Plastics (table).

Thermopylae was the name of a mountain pass in ancient Greece. The word *Thermopylae* means *Hot Gates.*

The name comes from hot springs near the narrow pass. Greek history tells the story of the bravery that was shown at Thermopylae, where gallant Greek warriors fought against their enemies, the Persians. The mountain pass no longer exists. The area is now a wide, marshy plain. But the hot springs remain.

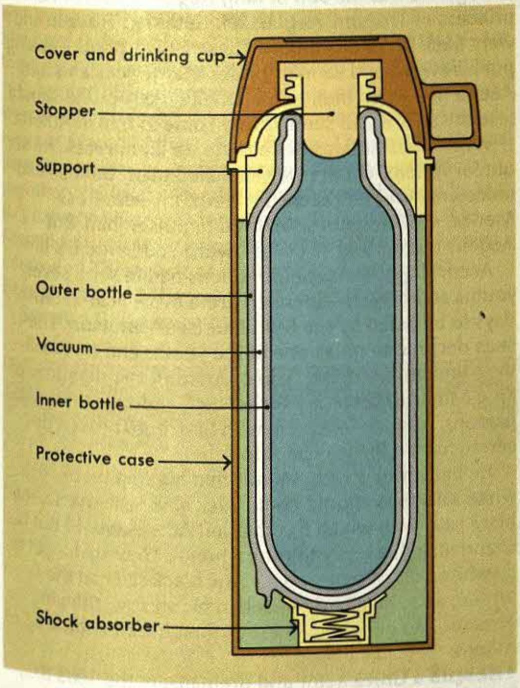
The narrow mountain pass lay between Mount Oeta and the Maliac Gulf. In ancient days, it provided the best way for an army to pass from northern into southern Greece. The pass was only about 15 metres wide, and fairly small forces were able to defend it.

In 480 B.C., Xerxes led his Persian warriors in an attempted invasion of Greece. The Greek states united to meet the attack. Leonidas, the king of Sparta, led the Greek army of 6,000 men to hold the pass at Thermopylae. The Greek fleet at Artemisium protected the forces of Leonidas from a Persian attack by sea.

For two days, the Greeks held the Persian foe at bay. But on the evening of the second day, a Thessalian traitor named Ephialtes showed Xerxes a new path over the mountains. The Persians crossed and threatened the Greeks from the rear. To save them from death in the pass, Leonidas ordered most of the Greeks to leave. He held off the Persian warriors with a small force of about 300 Spartans and 1,100 other Greeks. But the Persians outflanked him and killed Leonidas and most of his forces.

See also **Greece, Ancient** (The Persian Wars); **Leonidas I; Xerxes I.**

Thermos flask is a container that keeps liquids hot or cold for many hours. It is also called a *vacuum flask* or *Dewar flask.* Thermos bottles vary widely in size, ranging in capacity from 60 millilitres to 60 litres, and have many uses. They are commonly used to carry coffee, juice, milk, or soup. Vacuum flasks also are used in scientific and medical work to store chemicals and drugs, to transport tissues and organs, and to preserve blood plasma.



A thermos flask is two bottles in one, as shown above. A vacuum in the space between the inner and outer flasks helps prevent heat from passing through the bottle.

Sir James Dewar, a British chemist, invented the vacuum flask in 1892. He developed it for storing liquefied gases. Although his flask was designed to prevent the entry of heat from outside the container, it worked equally well in keeping liquids hot by reducing the loss of heat from the inside.

The modern thermos flask has the same basic design as Dewar's flask. It blocks the three processes through which heat is transferred—*conduction, convection,* and *radiation* (see **Heat** [How heat travels]). A typical thermos flask has an inner container that consists of two glass flasks, one within the other. Glass does not transmit heat well, and so reduces heat transfer by conduction. The flasks are sealed together at their lips by melting the glass. Most of the air between the flasks is removed to create a partial vacuum. This vacuum hinders heat transfer by convection because it has so few air molecules to carry heat between the flasks. The facing surfaces of the flasks are coated with a silver solution. They act like mirrors and reflect much of the heat coming from either the inside or outside of the container back to its source. In doing so, they prevent heat transfer by radiation.

Other features of thermos flasks help minimize both the loss or entry of heat. Most thermos flasks have a small mouth, which reduces heat exchange. The flasks are closed with a stopper made of cork, plastic, or some other material that conducts heat poorly. The fragile inner container of a thermos flask is encased in metal or plastic for protection. A rubber collar around the mouth holds the inner container in place, and a spring at the base serves as a shock absorber.

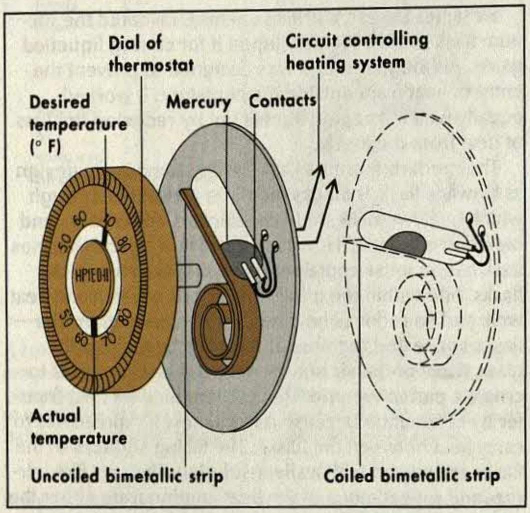
Thermosphere is the uppermost region of the earth's atmosphere. It begins at an altitude of about 85 kilometres and continues about 480 kilometres into space. The thermosphere has only a tiny fraction of the gases that are in the atmosphere. As a result, the atmospheric pressure in the lower thermosphere is a million or more times as low as the pressure at sea level.

The thermosphere is completely exposed to the sun's radiation. The radiation heats the thin atmosphere of the thermosphere to high temperatures. The temperature increases rapidly from about −93° C at an altitude of 89 kilometres to more than 1500° C in the *thermopause,* the upper region of the thermosphere.

Solar radiation, along with cosmic rays, changes the chemical composition of the atmosphere in the thermosphere. From 80 to 97 kilometres up, oxygen molecules are broken into atoms. Beyond 400 kilometres up, the thermosphere consists chiefly of helium and hydrogen atoms. The radiation also *ionizes* (charges electrically) atoms in the atmosphere. The region of ionized particles, called the *ionosphere,* extends into the thermosphere.

See also **Air; Troposphere; Stratosphere; Mesosphere; Ionosphere.**

Thermostat is a device that helps control the temperature of an indoor area or of an appliance. Thermostats are used in many kinds of equipment, including air con-


Dial of thermostat
Circuit controlling heating system
Desired temperature (° F)
Mercury
Contacts
Actual temperature
Uncoiled bimetallic strip
Coiled bimetallic strip

How a home thermostat works When the temperature in a room becomes too cold, the bimetallic strip of the thermostat uncoils. This action causes a drop of mercury to close a circuit and start the heating system. After the temperature has risen to the desired level, the strip has coiled up and the mercury breaks the circuit, shutting off the heat.

ditioners, heaters, electric blankets, ovens, and refrigerators.

A thermostat is set to keep an area or an appliance at a certain temperature. It measures temperature changes and automatically controls the heating or cooling unit of the equipment being used. For example, the thermostat in a home heating system turns on the boiler if the temperature drops below the desired level. It shuts off the boiler when the temperature reaches that level.

How thermostats work. Most metals, liquids, and gases expand when their temperature increases. They contract when their temperature decreases. Some thermostats use such expansion and contraction to measure and control temperature.

Most thermostats used in home heaters and air conditioners have a *bimetallic strip* that "senses" changes in temperature. This thin strip consists of two metals fastened together. When the temperature rises, each metal expands at a different rate, causing the strip to bend. The metals contract unequally when the temperature drops. These actions cause the strip to bend in the opposite direction. This bending action opens or closes the electric circuit that controls heating or cooling equipment. In some thermostats, the bending of the strip tilts a bulb filled with mercury. When the bulb tilts, it completes or breaks the circuit.

Some thermostats use the expansion or contraction of a gas or a liquid to control heating or cooling equipment. Other types use electric devices or infrared detectors that sense temperature changes.

Most thermostats turn heating or cooling equipment completely on or completely off. But some use a method called *proportional control.* These thermostats measure the difference between the actual temperature and the desired temperature. They change the amount of heating or cooling in proportion to this temperature difference. Proportional control thermostats can provide an extremely even temperature. They are used in industry and scientific research to control the temperature so that certain chemical processes can take place.

Uses. Thermostats that control air-conditioning and heating systems in houses and other buildings help keep the air comfortable for any activity. Some industries use thermostats to carefully control the temperature needed for manufacturing certain products or for scientific experiments.

Thermostats help keep refrigerators and freezers at the necessary temperature to keep food from spoiling. They control the temperature of household ovens and of industrial furnaces used in making such products as bricks and steel. In homes, thermostats are used in irons, hot water heaters, and heaters for fish tanks.

Thermostats also control the flow of water in car cooling systems. The thermostat operates a valve that opens when the water reaches a certain temperature. The open valve allows water to circulate through the radiator and through the water jacket that surrounds the engine.

Theropod. See **Dinosaur** (Saurischians).

Therry, John Joseph (1790-1864), a Roman Catholic priest, landed with his superior, Philip Conolly, in Sydney in 1820. They were the first officially recognized Roman Catholic missionaries to arrive in Sydney. Father Conolly went to Hobart, Tasmania in 1821, leaving Therry as the only priest on the mainland until 1826. Therry founded St. Mary's Church, later St. Mary's Cathedral, in Sydney in 1821. He built schools in Sydney and Parramatta in 1824. He also built churches in Hobart and Launceston. Therry was born at Cork, in Ireland.

Theseus was a great king of early Athens in Greek mythology. He was the son of King Aegeus and Aethra, a princess of Troezen. Aegeus left Aethra in Troezen and went back to Athens before Theseus was born. The king put his sword and sandals under a large rock and told Aethra that when their son could lift the rock, he should take the sword and sandals and come to him in Athens.

When Theseus was old enough to lift the rock, he set out for Athens. On the way, he killed many bandits and monsters. After he reached Athens, the sorceress Medea, now Aegeus' wife, tried to poison him. But Aegeus recognized Theseus' sword and saved his life.

According to the legend, Athens had to send seven youths and seven maidens to Crete every year in those days to be eaten by the Minotaur (see **Minotaur**). Theseus decided to go as one of the youths and try to kill the Minotaur. With the help of Ariadne, the daughter of King Minos of Crete, he succeeded, and saved his companions. Ariadne left Crete with him, but Theseus deserted her on the way back to Athens.

He had agreed with Aegeus that his ship would fly white sails if he should come back alive. Otherwise, the black sails with which the ship left Athens would not be changed. In his hurry to return home, Theseus forgot to fly white sails. When Aegeus saw black sails on the returning ship, he killed himself in his sorrow, thinking Theseus had perished. Theseus then became the king of Athens.

Thespis a Greek actor and dramatist of the 500's B.C., helped to create drama as we know it. Today, actors are sometimes called *Thespians,* after his name.

Thespis was a real person. However, the ancient

Greeks made him a legend and assigned several "firsts" to him. They said he was the first to use a speaker performing a role in dialogue with the choral group. Tragedy seems to have developed from this character-chorus dialogue, so the Greeks concluded that Thespis invented tragedy. The Greeks also credited Thespis with introducing makeup in the form of white lead paint and, later, masks to be worn by performers.

The famous "Parian Marble" tablet records that, in about 534 B.C. in Athens, Thespis became the first to produce a tragedy at the major festival honouring the god Dionysus. Competitions in playwriting were held regularly at the festival after this time.

Thessalonians, Epistles to the, are the 13th and 14th books of the New Testament. They are both letters from the apostle Paul to Christians in Thessaloniki (now Salonika), Greece. Paul wrote the first letter from Corinth about A.D. 50. He wrote to encourage the Thessalonians in difficult times. Paul also explained that Christians who had died before the Second Coming of Jesus Christ would rise from the dead and be united with Jesus on the Coming. This letter is the earliest surviving letter of Paul and the earliest known Christian writing.

Some scholars doubt that Paul wrote the second letter. They believe it was written in his name by one of his followers. If Paul was the author, he wrote it shortly after writing the first letter. Its main purpose was to convince the Thessalonians that the Second Coming of Christ was not as near as they believed.

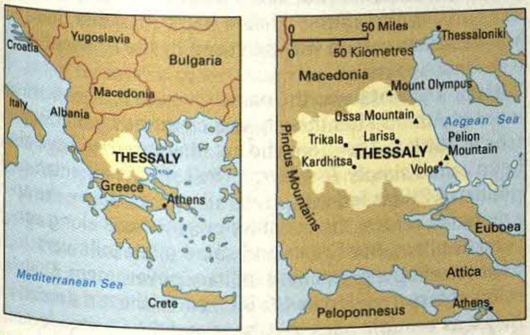
See also **Bible** (The New Testament); **Paul, Saint.**

Thessaloniki. See **Salonika.**

Thessaly is a region in northern Greece. It has an area of 13,903 square kilometres and a population of about 700,000 people. For location, see **Greece** (map). Volos and Larisa are Thessaly's largest cities. Three mountains that border the region—Olympus, Pelion, and Ossa—are important in Greek history and legend (see **Olympus**).

In legend, Thessaly was the home of the great Greek warrior Achilles, and also of Jason, who led the Argonauts in search of the golden fleece. The ancient Thessalians were weak militarily because they never banded together. Philip of Macedon conquered Thessaly in 344 B.C. Later, the Romans took Thessaly, and added it to Macedonia in 146 B.C. Venice and the Ottoman Empire controlled Thessaly for hundreds of years. In 1881, Greece acquired Thessaly from the Ottomans.

See also **Greece** (Land).



Thessaly is a region in northern Greece. The map on the left shows the location of the region. A map of Thessaly itself appears on the right.

Thiamine. See **Vitamin** (Vitamin B); **Beriberi.**

Thibault, Jacques A. F. See **France, Anatole.**

Thiele, Colin (1920-), an Australian writer, became known particularly for his children's books. These books include *Storm Boy* (1963), *February Dragon* (1965), *Blue Fin* (1969), *Magpie Island* (1974), *Chadwick's Chimney* (1980), *Seashores and Shadows* (1985), and *Stories Short and Tall* (1989). *Storm Boy* and *Blue Fin* were both made into films. Thiele won the Austrian State Prize for children's books for *The SKNUKS* in 1979 and for *Pinquo* in 1986. *Storm Boy* received the Netherlands Silver Pencil Award in 1986. His novel *The Valley Between* was the Australian Book of the Year in 1982.

Thiele's radio and television plays include *Burke and Wills, Edward John Eyre,* and *The Shark Fishers.* His books of verse include *In Charcoal and Conte* (1966) and *Man in a Landscape* (1960). *The Sun on the Stubble* (1961) is a humorous novel.

Thiele was born at Eudunda in South Australia and educated at Adelaide University. During World War II (1939-1945), he served in the Royal Australian Air Force. Thiele then worked as a teacher, a college lecturer, and finally as the director of various tertiary colleges before he retired in 1981.

Thiers, Louis Adolphe (1797-1877), was the first president of the Third Republic of France. His 10-volume *History of the French Revolution* (1823-1827) made him famous. He helped place Louis Philippe on the throne of France.

Thiers' political life included terms as foreign minister and president of the council. He also wrote a *History of the Consulate and the Empire* (1845-1862). Emerging from retirement in 1870 during the Franco-Prussian War, he negotiated the peace treaty with Otto von Bismarck, Germany's chancellor. Thiers then put down the revolt of the Paris Commune, and led the new republic until he resigned in 1873. He was born in Marseille, France.

See also **Franco-Prussian War.**

Thinker, The. See **Rodin, Auguste.**

Thiopental. See **Thiopentone sodium.**

Thiopentone sodium is a barbiturate used to produce sleep for surgery. It is a *general anaesthetic*—that is, a drug that causes unconsciousness and loss of feeling in the entire body.

The use of thiopentone as an anaesthetic was first publicly demonstrated in 1934 at the Mayo Clinic, Minneapolis, U.S.A. Thiopentone anaesthesia soon came into wide use, largely because thiopentone could be safely used in situations where flammable anaesthetics, such as ether and cyclopropane, produced a danger of fire or explosion. Today, thiopentone is used to induce anaesthesia for surgery throughout the world.

Thiopentone is usually administered by injection into a vein. Because receiving an injection is more pleasant for most patients than inhaling an anaesthetic, doctors use thiopentone to begin anaesthesia for surgery. After the patient is asleep, doctors usually maintain anaesthesia with nitrous oxide, halothane, or other inhalation anaesthetics. Intravenous anaesthesia alone may be used for procedures of short duration.

Psychiatrists sometimes give patients small doses of thiopentone. The drug helps patients discuss their thoughts and emotions more freely. For this reason, it is sometimes called a "truth serum."

Third International. See **International, The.**

Third Reich. See **Germany** (History); **Reich.**

Third World was a name sometimes given to economically developing countries, particularly those in Asia, Africa, and Latin America. The term *Third World* was also used for politically neutral countries. Such countries were often called *neutral nations* or *nonaligned nations* because they did not regularly support either side during the *Cold War.* The Cold War was a period of tension between non-Communist and Communist nations that began after World War II (1939-1945).

The term *First World* referred to several non-Communist countries, including the United States, other Western industrial nations, and Japan. The term *Second World* referred to the Soviet Union and other nations—especially in Eastern Europe—that had Communist governments during the Cold War. Some political experts considered China a Third World country, but others disagreed. The references to First World, Second World, and Third World began to lose their meaning when the Cold War reached an end in the late 1980's (see **Cold War**).

The Third World consisted of about 120 countries, which had more than half the world's population. Most Third World countries were former colonies of Western European nations and gained their independence after 1945. Most Third World countries also had an economy based on agriculture and developed few industries. Many exported raw materials to industrial nations in exchange for manufactured goods. In addition, most Third World countries were poor.

During the 1960's, Third World countries began to use the United Nations (UN) to promote their interests. The group of countries came to be known as the *Nonaligned Movement.* Today, this group has a majority of the votes in the UN General Assembly. A resolution cannot be adopted without the support of some of these countries.

After the mid-1970's, Third World countries increasingly emphasized their economic problems. They demanded financial aid and favourable trade agreements from the industrial countries in an effort to redistribute the earth's wealth. They considered the economic differences between developed and developing countries more important than the political differences between Communist and non-Communist ones. For this reason, they came to prefer the terms *North* for the wealthy nations and *South* for themselves. Most industrial nations, both Communist and non-Communist, were in the North. Most Third World nations were in the South.

Since the end of the Cold War, richer nations have been slow to meet the demands of Third World countries for assistance. Furthermore, the Eastern European nations and the republics of the former Soviet Union have begun to compete with Third World countries for aid. The World Bank and other international organizations provide funds for development in the Third World. But progress has been slow because Third World countries continue to suffer from rapid population growth and high rates of disease and illiteracy.

See also **Developing country.**

Thirst is a sensation caused by the body's need for water. The body's *internal environment* (the organs and tissues) needs certain amounts of water and salts to function properly. Too much or too little water or salt can damage or destroy cells. Therefore, people and animals must control their water intake.

People often describe thirst as a dry feeling in the throat. A lack of sufficient saliva can produce this kind of thirst, even when the internal environment has no need for water. In a similar way, the thirst sensation created by the internal environment's need will disappear briefly if water is drunk and wets the throat. But unless the water reaches the internal environment, thirst will recur after a short time. Human beings and other mammals usually drink liquids before any large change occurs in the internal environment.

The *sensory nerves* in the internal organs are affected by the volume of fluid in the internal environment. These nerves help regulate the amount of water drunk. The internal senses tell how much water and salt are inside and outside the body's cells (see **Senses**). One source of this information is a region of the brain stem called the *hypothalamus.* The hypothalamus is important in maintaining the internal environment. It contains nerve cells that respond to changes in the amount of salt in the blood. The salt concentration of the blood may indicate how much water is in body cells. For example, a decrease in body water produces an increase in the salt concentration in the blood. Thus, the amount of water in the internal environment also affects the amount of water eliminated from the body.

Thirty-Nine Articles were a statement of doctrine issued in England in 1563 and approved by Parliament in 1571. The Articles were created to settle religious disputes caused by the Protestant Reformation. The Articles set forth religious positions that all English people were expected to accept. They remain the doctrine of the churches of the Anglican Communion and are endorsed by the clergy of the Church of England.

The Articles set the Church of England on a middle ground between the Roman Catholic Church and various radical Protestant groups. The Articles condemned several Roman Catholic beliefs and practices, including purgatory, transubstantiation, reverence for saints and relics, indulgences, and the power of the pope. The Articles affirmed the doctrine of predestination—that people are saved solely by God's grace and cannot earn salvation by good deeds. The doctrine of free will was rejected. Contrary to the beliefs of the radicals, the Articles declared that Christians must obey *secular* (nonreligious) governments and could bear arms for the state. The Articles also affirmed infant baptism, rather than adult baptism, which was practised by the Anabaptists (see **Anabaptists**).

Thirty Tyrants was the name given to the government of Athens after the city was captured by the Spartans in 404 B.C. The men who ruled at this time have also been called simply *The Thirty.* The brilliant Athenian politician Critias led this powerful group. They were appointed to reform the constitution of Athens along conservative lines. But Critias and some of his followers tried to set up a permanent military government. Their reign of terror ended in 403 B.C., when the old democracy was brought back to Athens and the Spartan forces left the city. A group of pretenders who tried to gain control of the Roman Empire around A.D. 260 were also called the Thirty Tyrants.

Thirty Years' War (1618-1648) was a series of religious and political wars that eventually involved most European nations. The conflict began as a civil war between Protestants and Roman Catholics in the Holy Roman Empire and other territories under the administration of the Habsburgs, the royal family of Austria. But before the war ended, it had become a general struggle for territory and political power.

Causes of the war. The underlying cause of the war was the old deep-seated hostility between Protestants and Catholics in central Europe and in the Holy Roman Empire, a German-based empire that included what are now Germany, Austria, and parts of Italy and the Czech Republic. The Protestants and Catholics disagreed in their interpretation of the Peace of Augsburg (1555), which had been intended as a settlement of the religious question in the Holy Roman Empire. Both groups had violated the peace. In addition, the Peace of Augsburg had recognized only Catholics and Lutherans. There were many Calvinists and other Protestants in southern and central Germany, and they also demanded recognition.

The Bohemian period (1618-1624). A conflict over constitutional liberties between Protestants in Bohemia (now the western part of the Czech Republic) and their Roman Catholic rulers led to the war. But the spark that ignited the fighting came when the archbishop of Prague, the capital of Bohemia, ordered a Protestant church destroyed. In anger, the people appealed to Holy Roman Emperor Matthias, who ignored their protests. The Protestants revolted in May 1618 to defend their constitutional privileges. The rebels threw two of the emperor's officials out a window in what became known as the Defenestration of Prague. (*Defenestration* is from the Latin word *fenestra,* which means *window.*) Protestants in central Europe sided with the Bohemian rebels.

The Bohemian Protestants removed the Catholic king of Bohemia, Ferdinand, from the throne, and chose the Protestant Frederick, *elector* (prince) of the Palatinate, an area in Germany, in Ferdinand's place. But in 1619, Ferdinand was chosen Holy Roman emperor. Ferdinand—who took the title Ferdinand II—had great power in this position. In 1620, his general, Johan Tserclaes, Count of Tilly, decisively defeated the Bohemians in the Battle of the White Mountain. This defeat cost the Bohemians their independence, and Catholicism again became the state religion.

The Danish period (1625-1629). After Bohemia was defeated, the other Protestant countries began to realize their danger. The Protestant king of Denmark, Christian IV, aided by several other countries, opposed Ferdinand's forces in Saxony (now northern Germany). But the emperor had received unexpected help from the famous general Albrecht von Wallenstein, who had a large army of hired soldiers and adventurers.

Wallenstein's army, aided by forces of the Holy League, a military alliance of German Catholic states under the leadership of General Tilly, defeated the Danish king again and again. Christian IV signed the Treaty of Lübeck (1629) and withdrew from Saxony. Meanwhile, the emperor had issued the Edict of Restitution. It provided that all church possessions which the Protestants had acquired be returned to the Catholics. The edict marked the height of the emperor's power. But it forced other leaders in the empire to oppose him because he had issued the edict without consulting them.

The Swedish period (1630-1634). The Swedish king, Gustavus Adolphus, was devoted to the cause of Protestantism. He was also ambitious for Sweden, which would be in danger if Ferdinand became too powerful. So, for the first time, a major political issue entered the war. In 1630, Gustavus Adolphus set sail from Sweden with 13,000 men to relieve the city of Magdeburg, Germany, which Tilly was besieging. The Swedish king had the best-trained and best-disciplined army in Europe, but he arrived too late to prevent the capture, looting, and destruction of the city. In 1631, the Swedish army defeated Tilly in the Battle of Breitenfeld. Afterward, the Swedish forces won another important battle, and Tilly was killed in the fighting.

Emperor Ferdinand now called back Wallenstein, whom he had dismissed. Another army of recruits was gathered from many parts of Europe and placed under Wallenstein's leadership. Ferdinand also made an alliance with Philip IV of Spain. Wallenstein's army met the Swedish forces in the Battle of Lützen (1632). The Swedes won, but Gustavus Adolphus was killed in the battle.

The Swedes continued the struggle until 1634, when their army was destroyed in the Battle of Nördlingen. The emperor suspected that Wallenstein was negotiating with the Protestants and ordered his arrest. Wallenstein tried to escape but was assassinated.

The Swedish-French period (1635-1648). The war now lost most of its religious character and became largely political. Cardinal Richelieu, who ruled France through King Louis XIII, determined to block the growth of Habsburg power by interfering on the side of the Protestants. The war became a struggle between the royal Bourbon family of France and the Austrian Habsburgs. In 1635, Richelieu sent a French army into Germany, where it joined a Swedish army. The combined armies won a long series of battles, giving new hope to the Protestants in Germany.

The Peace of Westphalia (1648). For years the people of the Holy Roman Empire had suffered misery and hardship because of the Thirty Years' War. In 1644, the European countries sent representatives to a peace conference. The Catholic and Protestant delegates met separately in two different cities of Westphalia (now western Germany). The negotiations dragged on for four years, until the Peace of Westphalia was signed in 1648. By this treaty, France acquired Alsace and Lorraine; and Sweden got control of the mouths of the Oder, Elbe, and Weser rivers. Also as a result of the treaty, Calvinism was put on an equal footing with Catholicism and Lutheranism.

Results of the war. The Holy Roman Empire was in a pitiable condition by the time the war ended. Many people had been killed. Whole cities, villages, and farms had disappeared, and much property had been destroyed. Art, science, trade, and industry declined. It took almost 200 years for the German territories to recover from the effects of the war. Thousands of people left Europe, especially Germany, and went to America to build a new life.

See also **Gustavus Adolphus; Richelieu, Cardinal; Wallenstein, Albrecht W. E. von; Tilly, Count of.**

Thisbe. See **Pyramus and Thisbe.**

Thistle is the name given to a group of plants that have sharp spines or prickles. Thistles are often troublesome weeds. They grow in many places throughout the world. The most common thistles are the *creeping thistle,* the *spear thistle,* the *slender thistle,* and the *Scotch thistle.* They grow in pastures and grain and hay fields, and along roads, where the soil is rich. The most troublesome, the creeping thistle, is a perennial, that is, it grows year after year without replanting. The other three species are biennial, that is, they grow for only two years.

The thistle has sturdy stems, prickly leaves, and purplish flowers. This weed thrives in grain fields and is a troublesome pest.

Thistles have tough, fibrous stems, prickly leaves with many lobes, and soft, silky flowers, usually purple or pinkish-purple in colour. The flowers usually grow in round heads that form large, downy seed balls after the blossoms wither. The wind scatters the seeds, and this helps the thistles multiply rapidly. Some kinds have strong roots, and are hard to uproot. Root pieces left in the soil may produce new plants. Thistles are hard to remove from grain fields. Biennial species must be cut down before the flowers bloom. Chemicals that kill thistles but do not harm crops also can be used.

A number of plants similar to thistles are sometimes called thistles. Included among these is the *Russian thistle* or *tumbleweed.* This plant has become a serious pest in large areas of North America.

Scientific classification. Thistles belong to the family Compositae (Asteraceae). The most important genera of thistles include *Carduus, Cirsium,* and *Onopordum.* The creeping thistle is *Cirsium arvense;* the spear thistle, *C. vulgare;* the slender thistle, *Carduus tenuiflorus;* and the Scotch thistle, *Onopordum acanthium.*

Related articles in ***World Book*** include:

Blazing star
Boneset
Calendula
Camomile
Creeping thistle
Composite family
Fleabane
Sow thistle
Tumbleweed

Thomas, Dylan (1914-1953), was a Welsh poet who wrote some of the most stirring, passionate, and eloquent verse in modern literature. From the publication of his first book, *Eighteen Poems* (1934), critics recognized him as a brilliant and original poet. The volume bewildered and fascinated readers with its extraordinary verbal and musical energy and with its exploration of emotional extremes. These extremes, alternately ecstatic and morbid, revealed Thomas' obsessions with love, death, religion, and the sound of words.

Dylan Thomas

Thomas' high-spirited love of life and exuberant sense of humour are revealed in his prose fiction and drama as well as in his verse. *Portrait of the Artist as a Young Dog* (1940) is a collection of stories about Thomas' youth in Wales. A group of his symbolic stories was published as *Adventures in the Skin Trade* in 1955, after his death. *The Collected Stories of Dylan Thomas* was published in 1984. Just before his death, Thomas completed a radio play, *Under Milk Wood.* This play describes with tender humour a day in the life of eccentric residents of a Welsh village.

Thomas was born in Swansea, Wales. He gained great popularity through public readings of his works in Great Britain and the United States. Many of these readings are available on records and tapes. Thomas died of pneumonia aggravated by acute alcoholism while he was on a tour of the United States.

Thomas, Edward (1878-1917), was a British poet and critic. Born in London of Welsh parents, he graduated from Oxford University in 1900. Thomas earned his living mainly by writing reviews. His poems are sensitive, subjective, and often sad. They reveal his passion for nature and the countryside. Thomas's books include *The Woodland Life* (1897), *Rest and Unrest* (1910), and *Light and Twilight* (1911). Thomas enlisted in 1915 and was killed at Arras, in France, during World War I.

Thomas, George (1908-), Viscount Tonypandy, was speaker of the House of Commons in Britain's Parliament, from 1976 until 1983. He had been deputy speaker since 1974. Thomas George Thomas was born in Tonypandy, in Mid-Glamorgan, Wales, and was educated at Southampton University. He was first elected to Parliament for the Labour Party in 1945 and held several junior ministerial posts. Thomas served as secretary of state for Wales from 1968 to 1970.

Thomas, Isaiah (1749-1831), was the leading printer and publisher in colonial America. His Boston newspaper, the *Massachusetts Spy,* printed strong attacks on the British government.

Thomas was born in Boston, Massachusetts, U.S.A., and became a printer's apprentice there. He began to publish the *Spy* in 1770. In 1775, the British tried to stop the publication of patriot newspapers. Thomas sent his printing equipment by night to Worcester, Massachusetts, about 65 kilometres west of Boston. He arrived there a few days later. On the way, he aided the American patriot Paul Revere in his famous midnight ride and fought at Lexington and Concord in the opening battles of the American Revolution.

Thomas later printed books and magazines in addition to his newspaper. He wrote a book, *The History of Printing in America* (1810), which still ranks as an important work on the subject.

See also **Mother Goose.**

Thomas, Saint, was one of the 12 apostles of Jesus Christ. He is mentioned often in the Gospel of John, where he is also called *Didymus,* which means *the Twin* in Greek. Thomas encouraged the apostles to go with Jesus into Judea, despite the danger of persecution (John 11:16). When Jesus spoke of His death and Resurrection at the Last Supper, Thomas wanted to know how he and the other apostles could follow Him (John 14:5). Thomas is also known as "Doubting Thomas" because he refused to believe the report of Jesus' Resurrection unless he could touch His wounds (John 20:24, 25). When Jesus allowed him to feel His hands and His side, Thomas became a believer, saying, "My Lord and my God" (John 20:26-29).

According to later traditions, Thomas preached in Parthia or India. He was reportedly martyred in India. His feast day in the Roman Catholic Church is July 3. The Eastern Orthodox Churches celebrate his feast on the first Sunday after their Easter celebration.

See also **Apostles.**

Thomas à Becket. See **Becket, Saint Thomas à.**

Thomas à Kempis (1380?-1471) was a medieval monk and religious writer. He is generally considered the author of *Imitation of Christ,* probably the most widely read work of Christian literature other than the Bible. *Imitation of Christ* has been translated into many languages. The work first appeared in manuscript form in about 1424.

In *Imitation of Christ,* Thomas wrote that people can achieve grace only by trying to imitate the spirit and the actions of Jesus Christ. Thomas stated that grace could be attained through prayer, contemplation, the sacraments, and the rejection of worldly goods. He also emphasized the importance of humility, penitence, and self-discipline. In *Imitation of Christ,* Thomas drew on the writings of earlier Christian writers and the Bible. He also borrowed from the works of the Greek philosopher Aristotle and the Roman authors Ovid and Seneca.

Thomas was born in Kempen, near Krefeld, Germany. His original name was Thomas Hemerken. In school, people called him *Thomas from Kempen.* This eventually became *Thomas à Kempis.* Thomas completed his education in Deventer, the Netherlands. In 1399, he entered the Brethren of the Common Life at Mount St. Agnes, near Zwolle, the Netherlands. He was ordained in 1413.

Thomas Aquinas, Saint. See **Aquinas, Saint Thomas.**

Thompson, Andrew (1773-1810), a former convict, became the most successful grain grower and one of the wealthiest settlers in New South Wales, Australia. Thompson operated a store and an inn, and built the first toll bridge over South Creek at Windsor, New South Wales. He also operated four ships, which carried grain, fruit, and vegetables to Sydney and took convicts to the Hunter Valley.

Thompson was born at Kirk Yetholm, in Scotland. In 1790, he was sentenced to 14 years transportation for stealing cloth. Thompson arrived in Sydney in 1792 and was put to work in the men's provision store. The next year, he was appointed to the police force. In 1796, Governor Hunter appointed him to Green Hills (now Windsor), where he remained for the rest of his life. He was pardoned in 1798.

Thompson, Daley (1958-   ), is one of Britain's most outstanding all-round athletes. In both the 1980 and 1984 Olympic Games, he won a gold medal in the *decathlon,* a strenuous, two-day competition consisting of 10 different athletics events. Thompson broke the world record for the highest decathlon score three times. He also won gold medals in the decathlon at the World Championships in 1983, the European Championships in 1982, and the Commonwealth Games of 1978 and 1982. Francis Daley Thompson was born in London.

Thompson, David (1770-1857), a Canadian geographer and explorer, travelled the Columbia River from its source in Canada to its mouth in the United States. He explored extensive areas of Canada, and surveyed the northernmost source of the Mississippi River in the U.S.A. From 1816 to 1826, he was a surveyor on the U.S.-Canadian boundary.

Thompson was born in Westminster, London, England, and was apprenticed to the Hudson's Bay Company when he was 14 years old. He worked for the North West Company from 1797 until 1812.

Thompson, Francis (1859-1907), was an English poet whose emotional poems reflect his intense Roman Catholic faith. His most famous work is "The Hound of Heaven" (1893). This poem represents Jesus Christ as a kind hunter who pursues and finally captures the fleeing soul of the poet. Thompson's intensity and bold imagery are closer to the poets of the 1600's than to those of his own time. Thompson also became noted for his prose writings, especially his literary criticism.

Francis Joseph Thompson was born in Preston, Lancashire, England. At the age of 11, he began studying to become a priest but stopped his training six years later. His parents then expected him to become a doctor like his father, but Thompson disliked medical school and gave up medicine for poetry. He cut himself off from his family and settled in London in 1885. There he suffered from illness and extreme poverty and eventually became addicted to opium. He was befriended by the writers Alice and Wilfred Meynell, who helped him overcome his addiction.

Thomsen, Christian Jürgensen (1788-1865), was a Danish archaeologist. He was one of the first to demonstrate that the vast history of humankind, before written records began, could be divided into a Stone Age, a Bronze Age, and an Iron Age. His interest in bringing this understanding to the public led him to organize the world's first ethnographical museum, in Copenhagen, Denmark, in 1846.

Thomson, Lord (1894-1976), Roy Herbert Thomson, Baron Thomson of Fleet, was a leading newspaper owner. He also launched Scotland's first independent television company. He was born in Toronto, Canada. He began his career by selling radio sets, then opened a chain of radio stations to improve business. He bought his first newspaper at the age of 40 and eventually became one of Canada's leading newspaper owners. In 1953, Thomson settled in Britain and bought *The Scotsman.* In 1959, he bought Kemsley Newspapers, which included the *Sunday Times.* He became a British citizen in 1963 and received a peerage in 1964. In 1966, he acquired a controlling interest in *The Times.*

Thomson, Charles Wyville. See **Exploration** (Deep-sea exploration).

Thomson, George (1921-), Baron Thomson of Monifieth, served from 1973 to 1977 as a Common Market commissioner with special responsibility for regional policy. George Morgan Thomson was born in Stirling, Scotland, and educated at Grove Academy, Dundee. As a British Labour MP from 1952 to 1972, he was twice chancellor of the Duchy of Lancaster (1966 and 1969). He also served as secretary of state for commonwealth affairs (1967-1968). As deputy foreign secretary in 1969-1970, he handled negotiations for Britain's entry into the Common Market. Thomson became a life peer in 1977.

Thomson, James (1700-1748), was the most celebrated Scottish poet of the 1700's until Robert Burns. In 1725, he travelled from Scotland to London, where he published his masterpiece, *The Seasons* (1726-1730, revised 1744-1746). Thomson broke with the witty artificial poetic style of his day. He turned to nature for his subject matter and wrote fresh, vivid descriptions of natural scenes in rich blank verse. This style led to the romantic movement later in the 1700's.

Thomson was born in Ednam in the Scottish lowlands. He wrote tragedies, the poem *Liberty* (1735-1736), and an imitation of the poetry of Edmund Spenser, *The Castle of Indolence* (1748).

Thomson, Sir Joseph John (1856-1940), a British physicist, received the 1906 Nobel Prize for physics for his discovery of the electron. In 1937, his son and pupil, Sir George Paget Thomson, shared the Nobel Prize for physics with Clinton Davisson, an American physicist.

Thomson began in 1895 to investigate the mysterious rays that occurred when electricity was passed through a vacuum in a glass tube. Because the rays seemed to come from the *cathode* (negative electrical pole in the tube), they were called *cathode rays.* No one had succeeded in deflecting them by an electric force. Some scientists therefore assumed that cathode rays were like light waves. Thomson believed that they were really tiny particles of matter (see **Cathode rays**).

Thomson built a special cathode-ray tube in which the rays passed through electric and magnetic fields that were perpendicular to each other. The rays became visible as a dot on the opposite end of the tube. By measuring the deflections of the dot as he changed the strength of the electric and magnetic fields, Thomson determined the ratio of the charge to the mass of the particle (symbolized as *e/m*). From the direction of their deflection, he decided that the particles were negatively charged. Because their *e/m* was always the same, he felt sure that they were a fundamental part of all atoms. These particles were later called *electrons* (see **Atom** [diagram: Models of the atom]; **Electron**).

Thomson was also the first to separate isotopes of the chemical elements. This accomplishment spurred the invention of the mass spectrograph by his assistant, Francis W. Aston (see **Mass spectroscopy**).

Thomson was born near Manchester, England, and was educated at Manchester and Cambridge. Thomson's experimental work was invaluable to physics. His theoretical model of the atom, however, became obsolete after new models were proposed by Ernest Rutherford in 1911 and Niels Bohr in 1913.

See also **Electronics** (picture: The discoverer of the electron).

Thomson, Tom (1877-1917), was a Canadian landscape painter. He was associated with, and greatly influenced, J. E. H. MacDonald, A. Y. Jackson, and the other Canadian artists who, after 1920, called themselves "the Group of Seven."

For eight months of each year, Thomson lived in Algonquin Park, Ontario, Canada, painting and serving as a ranger. During the winters, Thomson lived in Toronto, where he painted from his sketches the few large pictures that he completed. The pictures portray the beauty and imposing grandeur of the Canadian wilderness. They are characterized by a brilliance of colour and a free dashing treatment seldom equalled. His first work to be exhibited, *Northern Lake,* was purchased by the National Art Gallery in Ottawa. Thomson was born near Owen Sound, Ontario. He accidentally drowned in Algonquin Park in 1917.

Oil painting on canvas (1917); National Gallery of Canada, Ottawa, Canada

Tom Thomson's *The Jack Pine,* one of his brilliant landscapes, portrays the beauty of Canada's wilderness.

See also **Canada** (The arts [picture]); **Group of Seven** (picture).

Thomson, Virgil (1896-1989), was an American composer and music critic. He gained international fame with his first opera, *Four Saints in Three Acts* (1934). Thomson also became famous for his simple, almost hymnlike style and subtle humour in music.

Thomson was born in Kansas City, Missouri, U.S.A. From 1925 to 1940, he lived in Paris. There, he was influenced by Erik Satie and other modern French composers. Thomson's *Missa Pro Defunctis* (1960), a religious composition for chorus, shows Satie's influence. In Paris, Thomson and American writer Gertrude Stein became friends. They collaborated on two operas, *Four Saints in Three Acts* and *The Mother of Us All* (1947). In New York, he composed the opera *Lord Byron* (1972) with Jack Larsen.

Thomson was a pioneer among concert composers in writing music for films. He composed the music for two famous documentary films, *The Plow That Broke the Plains* (1936) and *The River* (1937). Thomson won the 1949 Pulitzer Prize for his film score for the documentary *Louisiana Story* (1948). His other works include many compositions that he called portraits, such as *The Mayor La Guardia Waltzes* (1942), and such descriptive pieces as *The Seine at Night* (1947).

From 1940 to 1954, Thomson served as music critic of the *New York Herald Tribune*. His literary style and insight into modern music made him one of the most respected critics of his time. Thomson wrote several books, including *The State of Music* (1939) and *Music, Right and Left* (1951). He also wrote an autobiography, *Virgil Thomson* (1966).

Thomson, William. See **Kelvin, Lord.**

Thor, the god of thunder and lightning, was the ruler of the sky in Norse mythology. He was the oldest and most powerful son of Odin, the king of the gods and goddesses. Thor had great strength and was a skilled fighter. His chief weapon was a hammer named Mjollnir, which he threw at his enemies. Mjollnir never missed its mark and always returned to Thor after hitting a target. Thor created lightning whenever he threw Mjollnir, and thunder was the rumbling of his chariot as it moved across the sky. The day Thursday was named after Thor.

Of all the Norse gods, Thor best represented the way of life of the ancient Vikings. For example, the Vikings held great feasts and glorified war. Several myths describe Thor's huge appetite. He once ate an ox and eight salmon and drank three barrels of an alcoholic beverage called mead. Another myth tells of a drinking contest in which Thor tried to drink the sea dry. He failed to do so, but he lowered the level of the sea slightly and thus created the first tides. The gods had several huge drinking horns, and only Thor could consume their entire contents.

Many myths tell of Thor's encounters with the giants, the chief enemies of the Norse gods and goddesses. One story describes his battle with Hrungnir, a giant, who hurled a huge stone at him. Thor threw his hammer, and it shattered the stone in the air and killed Hrungnir.

One day, according to Norse mythology, the gods and goddesses will fight the giants in a great battle called *Ragnarok,* and the world will be destroyed. Thor and the Midgard Serpent, a vicious snake coiled around the world under the sea, will kill each other during the battle.

See also **Mythology** (Teutonic mythology).

Thoracic duct. See **Lymphatic system.**

Thorax. See **Chest; Insect** (The bodies of insects).

Thoreau, Henry David (1817-1862), was an American writer who is remembered for his attacks on the social institutions he considered immoral and for his faith in the religious significance of nature. The essay "Civil Disobedience" is his most famous social protest. *Walden,* a study of people in nature, is chiefly responsible for his literary reputation.

His life. Thoreau was born in Concord, Massachusetts, U.S.A., on July 12, 1817. Unlike most leading writers of his time, Thoreau came from a family that was neither wealthy nor distinguished. His father made pencils in a small shop. His mother took in boarders.

Henry David Thoreau by Samuel Rowse. Concord Public Library, Concord, Massachusetts, U.S.A.

Henry David Thoreau

Thoreau graduated from Harvard College in Boston, Massachusetts, in 1837. He soon met the writer Ralph Waldo Emerson, who encouraged him to write, gave him useful criticism, and later employed him as a gardener and handyman. Emerson also taught Thoreau the philosophy of *transcendentalism,* with its emphasis on mysticism and individualism (see **Transcendentalism**).

Thoreau published only two books during his lifetime, *A Week on the Concord and Merrimack Rivers* (1849) and *Walden* (1854). Many of the books that were published after his death were based on trips he had taken. These books include *Excursions* (1863), *The Maine Woods* (1863), *Cape Cod* (1865), and *A Yankee in Canada* (1866). The books are organized in a loose chronological form that takes the reader through the author's experiences.

His beliefs and works. Thoreau believed that people must be free to act according to their own idea of right and wrong, without government interference. In "Civil Disobedience" (1849), he said that people should refuse to obey any law they believe is unjust. Thoreau practised this doctrine of *passive resistance* when, in 1846, he refused to pay poll taxes. He did so to express his opposition to slavery as it became an issue in the Mexican War. He spent a night in jail as a result of his action.

Thoreau summed up his idea of the role of government in "Civil Disobedience." He wrote, "There will never be a really free and enlightened State until the State comes to recognize the individual as a higher and independent power, from which all its own power and authority are derived, and treats him accordingly." The

Walden Pond, near Concord, Massachusetts, U.S.A., inspired Thoreau's most famous book. He built a cabin near the pond.

essay greatly influenced such reformers as Leo Tolstoy of Russia, Mohandas Gandhi of India, and the leaders of the present-day American civil rights movements.

Thoreau called for an end to slavery. He attacked it in the essay "Slavery in Massachusetts" (1854), and defended abolitionist John Brown's raid at Harpers Ferry, West Virginia, U.S.A., in "A Plea for John Brown" (1859).

In 1845, Thoreau moved to the shore of Walden Pond near Concord, Massachusetts. He lived there alone from July 4, 1845 to Sept. 6, 1847. *Walden* records Thoreau's observations of nature there, and tells how he built his house, paid his bills, and spent his time. It also tells about his visitors, and reports what he read and thought. On a deeper level, the book is a celebration of people living in harmony with nature.

Thoreau insisted that his trip to Walden Pond was an experiment in simple living, not an idle withdrawal from society. He wrote, "The mass of men lead lives of quiet desperation." He appealed to people to economize, to simplify their lives, and thus to save the time and energy that will allow them "to live deep and suck out all the marrow of life. . . ."

Thorium is a radioactive chemical element with symbol Th. It is a soft metal with a silvery lustre. Thorium has 12 isotopes, the most stable of which has a mass number of 232 and a half-life of 14 billion years. When thorium is bombarded with neutrons, it changes to uranium-233, a nuclear fuel. U-233 is used in bombs and nuclear reactors. Thorium is also used in making strong alloys. In addition, manufacturers use thorium in special photoelectric cells designed to measure ultraviolet light. The mantles of some camping lanterns are also made of thorium. The mantles give off a bright light when heated by a gas flame.

Thorium occurs in various minerals, including monazite and thorite. These minerals are mined chiefly in Brazil, India, and South Africa.

The atomic number of thorium is 90 and its atomic weight is 232.038. Thorium metal melts at 1750° C and boils at about 4000° C. The Swedish chemist Jöns J. Berzelius discovered thorium in 1828. The element is named after the Norse god Thor.

See also **Uranium** (Uranium isotopes); **Monazite.**

Thorn is a short, sharp, modified stem that grows out of the woody stems of many species of trees and shrubs. The blackthorn, hawthorn, and pyracantha are examples of plants that bear thorns. Thorns have a short growth period that ends with the formation of a sharp, hardened tip. The thorns protect the plant from damage by grazing animals. Plants with thorns are common in dry, warm areas, such as deserts and savannas.

Thorns are often confused with similar structures that grow from the stems of certain plants. The "thorns" of rose plants are better called prickles because they are simple outgrowths of the surface of the stem. The thornlike structures on such plants as black locust and barberry are actually modified leaves and should be called spines.

Thorn apple. See Datura.

Thorndike, Edward Lee (1874-1949), an American educational psychologist, made many contributions to the study of learning, teaching, and mental testing. He invented the puzzle-box to investigate how such animals as cats and dogs solve problems. He found that they tend to repeat only those movements that are successful. This leads them to a final quick solution.

Thorndike also studied learning in human beings. He found that being right helped the student to retain a correct response, but that being wrong did not seem to eliminate errors. He conducted large-scale statistical studies to show how the study of Latin, mathematics, and other subjects affects the later school performance of students. He was one of the first to devise tests to measure learning and aptitudes.

Thorndike was born in Williamsburg, Massachusetts, U.S.A. He received a Ph.D. from Columbia University, New York City, and taught at Teachers College, Columbia University, for 41 years. He developed a method to determine which words are used most often. His data was used as a basis for the Thorndike-Century and the Thorndike-Barnhart school dictionaries. His *Teacher's Word Book* (1944) lists 30,000 words by their frequency of use. His other works include *Mental and Social Measurement* (1904), *The Measurement of Intelligence* (1926), *Fundamentals of Learning* (1932), and *The Psychology of Learning* (1941).

Thorndike, Dame Sybil (1882-1976), was a distinguished British actress. Her versatility was shown by her appearances in modern comedy, Greek tragedy, poetic drama, and classics from many countries. From 1914 to 1918, she was at the Old Vic Theatre in London, where she played a long series of roles in Shakespeare's plays. During World War II, she toured British mining towns and villages.

Dame Sybil Thorndike

Sybil Thorndike was born at Gainsborough, in Lincolnshire, England. In 1961, she was made a Dame Commander of the Order of the British Empire.

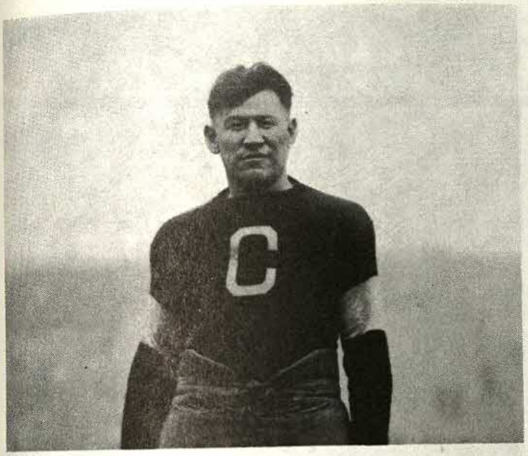
Thornhill, Sir James (1675-1734), was an outstanding British mural painter. Between 1715 and 1717, he decorated the dome of St. Paul's Cathedral, London. His other works include the decorations in the Painted Hall at Greenwich Hospital and Queen Anne's bedroom at Hampton Court. Thornhill was born at Melcombe Regis, in Dorset, England.

Thoroughbred. See **Horse** (Saddle horses).

Thoroughwort. See **Boneset.**

Thorpe, Jeremy (1929-), was the leader of the Liberal Party from 1967 to 1976. John Jeremy Thorpe was born in London. He was educated in the United States and at Eton College and Oxford University, England. He qualified as a barrister in 1954. He became Liberal member of Parliament for North Devon in 1959. In 1979, Thorpe was acquitted of conspiring to murder a former friend, Norman Scott. He lost his parliamentary seat at the 1979 election.

Thorpe, Jim (1887-1953), was one of the greatest all-round athletes in history. He became an outstanding college and professional American football player and won fame as an Olympic athletics champion. Thorpe also played American major-league baseball.



Jim Thorpe became one of the first men to be admitted to America's National Football Foundation's Hall of Fame, in 1951.

In the 1912 Olympic Games, Thorpe became the first athlete to win both the pentathlon and the decathlon (see **Athletics** [The decathlon, heptathlon, and pentathlon]). But about a month later, Olympic officials took away his medals. Prior to the games, Thorpe had played baseball for a small salary. The Amateur Athletic Union ruled that Thorpe was therefore a professional athlete and ineligible to compete in the Olympic Games. In 1982, the International Olympic Committee restored Thorpe's gold medals and added his name to the list of 1912 Olympic champions.

James Francis Thorpe, an American Indian, was born near Prague, Oklahoma, U.S.A. Thorpe studied at the Carlisle (Pennsylvania) Indian Industrial School. He led the small school to national fame in American football. He was an outstanding runner, place kicker, and tackler, and won all-America honours in 1911 and 1912.

From 1913 to 1919, Thorpe played baseball as an outfielder for three American major league teams. Thorpe began his professional American football career in 1915. Thorpe helped establish professional American football as a popular sport. In 1920, Thorpe became the first president of the American Professional Football Association, now known as the National Football League.

Thorvaldsen, Bertel (1770-1844), was a Danish sculptor. His name is also spelled *Thorwaldsen.* During his lifetime, many people considered him the greatest sculptor in Europe. Thorvaldsen was a leader of the *neoclassical* movement. Neoclassical artists based their style and subjects on the classical traditions of ancient Mediterranean civilizations, particularly Greece. Like many painters and sculptors of his time, Thorvaldsen believed that imitation of ancient classical works of art was the surest way of becoming a great artist.

Thorvaldsen was born in Copenhagen, Denmark. He lived in Rome from 1797 to 1837, where he studied classical art at first hand. Thorvaldsen took many of his subjects from ancient literature and mythology. Like the ancient Greek artists, he tried to sculpt human figures with clear contours, smooth surfaces, pleasing proportions, and a feeling of tranquillity. Thorvaldsen created most of his works in white marble. They included relief sculptures, monuments, and portrait busts.

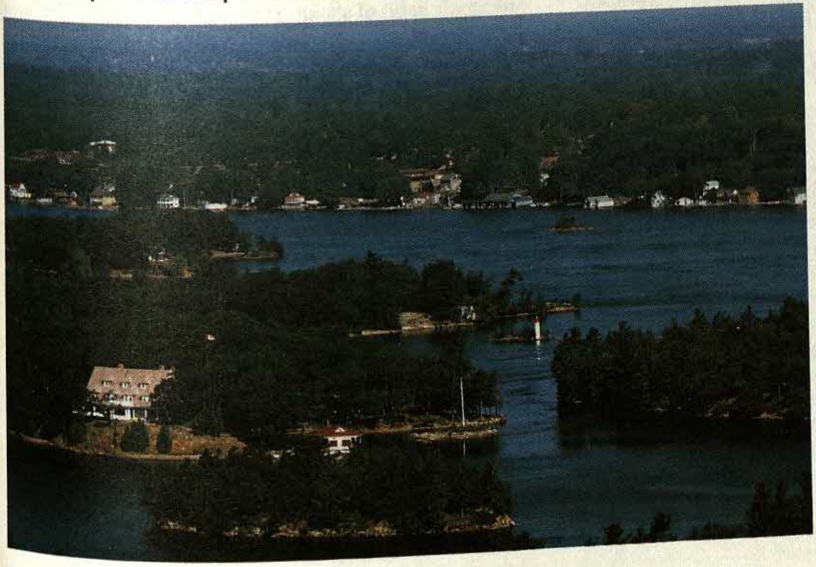
See also **Sculpture** (1600-1900; picture).

Thoth was an ancient Egyptian moon god. He was a patron of civilization and such intellectual arts as writing, astronomy, mathematics, law, magic, and healing. He is most often shown in art with a human body and the head of an ibis bird. He is also portrayed as a dog-headed baboon. Thoth's most important role in the underworld was to oversee the scales on which the souls of the dead were weighed to determine innocence or guilt. He was also related to many other gods. He was considered the scribe of the sun god Re and even Re's chief administrative officer. In the creation myth from Memphis, Thoth became the tongue of the creator god Ptah, through whom the world was created. See also **Mythology** (Egyptian mythology).

Thothmes III. See **Thutmose III.**

Thousand and One Nights. See **Arabian Nights.**

Thousand Islands is a group of more than a thousand islands in the Saint Lawrence River, in North America. No complete count has ever been made, because



The Thousand Islands occupy a 64-kilometre stretch of the St. Lawrence River as it leaves Lake Ontario, Canada. The rocky islands are noted for their beautiful scenery and mild summer climate.

some of the islands are only small points of rock above the water. But at least 1,700 islands compose the group. A few of the islands extend as much as 6 to 8 kilometres in length.

The islands lie in a 64-kilometre stretch of the Saint Lawrence where the river runs from 6 to 11 kilometres wide as it leaves Lake Ontario. They are formed where the river flows over the low hills of the Canadian Shield, which extends southeast into New York, U.S.A. (see **Canadian Shield**).

These rocky islands are noted for their beautiful scenery and mild summer climate. Many have popular public summer resorts. Several have luxurious summer homes. Seventeen of the islands are included in Saint Lawrence Islands National Park. The park has been made into a recreational centre and game preserve.

The Thousand Islands International Bridge, completed in 1938, spans some of the islands. It consists of two main suspension structures, three smaller bridges, and roadways across two islands. Its total length is about 10.5 kilometres.

Thrace was the ancient name for a large region in the Balkan Peninsula. It stretched from Macedonia north to the Danube River, and eastward as far as the Black Sea. The territory that was ancient Thrace is now divided among Bulgaria, Greece, and Turkey. The mountains of Thrace contained valuable deposits of gold and silver. Its broad plains were used for farming and for raising horses and cattle.

The people of Thrace were Indo-Europeans who liked warfare and looting. They grew rich from trading with Greeks who lived along the Thracian coast in the 600's B.C. The Persians occupied much of Thrace from 520 to 460 B.C. After that time, Thrace became independent and had much contact with the ancient Greeks. The Thracians adopted the Greek artistic style, and the Greeks adopted Thracian myths and religious beliefs. Later, Thrace belonged to the Athenian state and then to Macedonia. Philip II conquered all of Thrace, and the region was held by his son, Alexander the Great. Thrace became a province of the Roman Empire during the hundred years before Christ's birth.

The most important Greek cities of Thrace were Abdera, Sestos, and Byzantium. Ancient Byzantium was the foundation of the modern city of Istanbul (Constantinople). The fall of Constantinople in 1453 brought all Thrace under Turkish rule.

After the Russo-Turkish War of 1877-1878, northern Thrace became known as Eastern Rumelia and was united with Bulgaria in 1885. Greece took western Thrace during World War I (1914-1918). Turkey and Bulgaria control the rest of the region. German troops overran Greek Thrace in 1941, but it was given back to Greece after World War II (1939-1945). Greek Thrace includes the departments of Evros and Rhodope. Turkish Thrace corresponds to Turkey in Europe.

Thrasher is the name of a group of brownish, long-tailed birds found from southern Canada to South America. There are about 17 species of thrashers. The best-known species is the *brown thrasher* of eastern North America (see **Brown thrasher**). This bird's name probably comes from its habit of thrashing its long tail up and down, especially when it is excited. Most thrashers have a brown head and back, and a pale underside with brown streaks. The largest thrashers grow to more than 30 centimetres long.

The pearly-eyed thrasher, *above,* is common in the West Indies. These thrashers have a long, curved beak and live in trees. About 17 species of thrashers live in North and South America.

Thrashers spend most of their time on the ground searching for food. They eat insects and worms, as well as fruit and seeds. These birds have a loud, repetitive song. They build cup-shaped nests, usually in low bushes and shrubs, and lay from two to six eggs.

Eight species of thrashers range from western North America to Central America. Most of these have a long, curved bill. Species that inhabit arid regions of the Southwestern United States have longer legs and shorter wings. These species do more running than flying and nest in thorny shrubs or cactuses.

Four species live only in the West Indies. Two of them, the *white-breasted trembler* and the *brown trembler,* are in danger of extinction. Both of these species are nervous ground-dwellers. Tremblers are named after their habit of shaking the body and wings. The other West Indian species, the *pearly-eyed thrasher* and the *scaly-breasted thrasher,* dwell in trees. The pearly-eyed thrasher is the most common West Indian species. It nests in holes in trees.

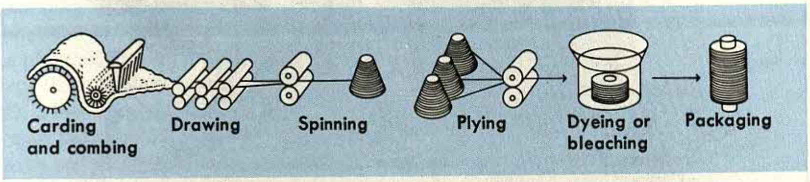
Scientific classification. Thrashers belong to the mockingbird family, Mimidae. The brown thrasher is *Toxostoma rufum,* the white-breasted trembler is *Ramphocinclus brachyurus,* the brown trembler is *Cinclocerthia ruficauda,* the pearly-eyed thrasher is *Margarops fuscatus,* and the scaly-breasted thrasher is *Allenia fusca.*

Thread is a fine cord. It is used chiefly to join two or more pieces of material or to sew an object to a piece of fabric. Thread is made of such fibres as cotton, flax, nylon, polyester, rayon, silk, or other textile material. Thread has numerous uses. These uses include sewing clothing, mending tears, and attaching buttons.

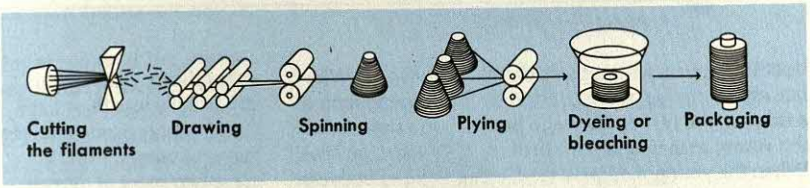
Most thread is made by spinning many fibres into a single yarn. Several yarns are then twisted tightly together to form thread. Each yarn, called a *ply,* adds strength and thickness to the thread. Some thread consists of only a single yarn.

How thread is made Thread may be made from natural or manufactured fibres. After preliminary processing, the fibres are drawn into strands, spun into yarn, and plied. Most thread is dyed or bleached before packaging.

Natural fibres used in making thread include cotton and flax. The carding and combing processes straighten the fibres and smooth them into a sheet before drawing begins.



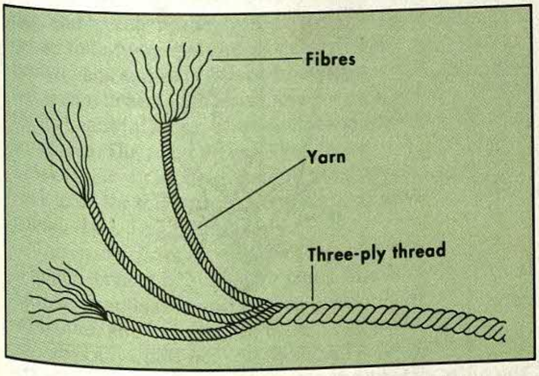
Manufactured fibres, such as nylon and polyester, are made in long continuous strands called *filaments.* To make thread, the filaments are cut into fibre-sized pieces before drawing.



Thread is made from three kinds of fibres: (1) plant, (2) animal, and (3) manufactured. Plant and animal fibres are called *natural fibres.* Almost all natural fibres grow in short lengths known as *staple.* For example, cotton staple measures from about 1 to 3.5 centimetres long or longer. Cotton ranks as the most widely used natural fibre for making thread. Manufactured fibres, such as nylon and polyester, are produced in long, continuous strands called *filaments.* Silk is the only natural fibre that begins as filament. Silk fibres average from about 900 to 1,200 metres long.

Most natural and manufactured thread goes through some kind of chemical treatment that improves its quality. One such process, called *mercerization,* treats cotton thread in a saltlike solution. This treatment strengthens the thread and gives it a silky finish. Most thread is also bleached or dyed before being packaged.

Making thread from natural fibres. Natural fibres, such as cotton or flax, are first cleaned. Then they are straightened and further cleaned in a process called *carding.* The next step, called *combing,* smooths the fibres and removes some of the exceptionally short fibres. The combed fibres pass between sets of powerful rollers, which draw many pieces of loosely joined fibres into continuous strands of increased strength. The strands are then spun into yarn and wound on bobbins. Several yarns are *plied* (twisted together) to form thread.



Thread consists of many fibres that have been spun into yarns. The yarns are *plied* (twisted together) to form thread.

Making thread from manufactured fibres involves few steps. Filaments need little preliminary processing because they are specifically produced to be made into thread. A single filament can be used as *monofilament thread,* or many filaments may be twisted together to form *multifilament thread.* Filaments may also be cut into staple lengths, which are drawn into strands and then spun into yarn and plied. This process produces a softer thread than that made directly from filaments.

One type of manufactured thread, called *core thread,* combines the qualities of two kinds of fibres. An example of such a thread is a blend of cotton and polyester. This thread is made by combining a core of multifilament polyester with a protective cotton *wrap.* The resulting strand is plied with two or more similar strands. This process gives the thread the smoothness of cotton and the strength of polyester. Core threads can be sewn on a machine faster than other manufactured thread without heating up and breaking. Core threads are ideal for sewing such textiles as knits, permanent-press fabrics, and fabrics that are made from two or more kinds of fibres.

See also **Spinning.**

Threadworm. See **Pinworm.**

Three-day measles. See **German measles.**

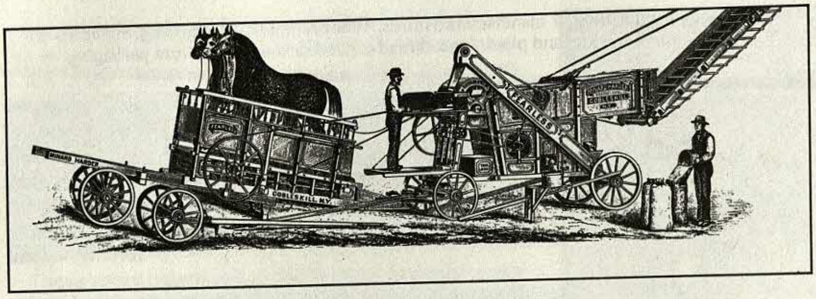
Three-dimensional picture. See **Holography; Stereoscope;** also the Trans-Vision three-dimensional pictures with the **Human body** article.

Three Mile Island. See **Nuclear energy** (Safety concerns).

Three-mile limit. See **Territorial waters; Right of search.**

Three Rivers (pop. 74,100) is a local government district in Hertfordshire, England. It contains the residential areas of Chorleywood and Rickmansworth. Many of the district's inhabitants work in London. The area has associations with Cardinal Wolsey and William Penn. See also **Hertfordshire.**

Three Sisters are huge formations of sandstone near Katoomba, in the Blue Mountains of New South Wales, Australia. The name comes from an Aboriginal tradition. A local mountain tribe had a well-known Aboriginal



Early threshing machines, such as the one on the left, were powered by horses walking on a treadmill. The clean kernels poured out of the machine into a bucket, and a conveyor belt carried the stalks away.

doctor, Tyawan, whose three daughters, Meenai, Wimlah, and Gunedee, were courted by three young men of a tribe on the plains. Marriage between the sisters and the young men would have broken strict marriage laws. When the young men persisted, a battle raged between these tribes on a cliff top. As Tyawan's family was driven to the cliff edge, he used magic to turn the three sisters to stone for their protection. He was killed before he could bring them back to life.

See also **New South Wales** (picture: The Blue Mountains).

Three Wise Men. See Magi.

Threshing machine is a machine that farmers once used to *thresh* (separate) kernels of grain from stalks. The machine also *winnowed* (blew) the husks from the kernels. Andrew Meikle of Scotland built the first practical threshing machine in the 1780's. Before then, farmers had threshed and winnowed by hand—a hard, slow task. Threshing machines enabled farmers to process grain much faster than they could by hand. Since the 1930's, combine harvesters have replaced most threshing machines (see **Combine harvester**).

Modern threshing machines were based on a type designed in the 1830's by two brothers, Hiram and John Pitts of Winthrop, Maine, U.S.A. Horses walking on a treadmill produced power for early threshers. A revolving cylinder knocked the kernels off the stalks, and a fan blew away the husks. The machine was stationary during operation. It cost so much that a group of farmers bought one thresher and shared it in harvesting their crops. By the late 1800's, steam engines powered most threshers. Later, farmers used their tractor motors to power threshing machines.

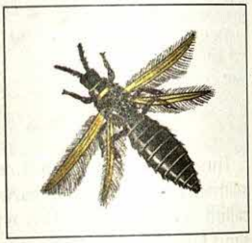
Thrifts are a group of colourful plants used in rock gardens and flower-bed borders. It includes the *thrift* (or *sea pink*) and the *sea lavender.* The thrift has narrow, evergreen leaves that grow in large bunches. Its small pink or white flowers grow in dense, globe-shaped clusters. The sea lavender has wider leaves and purple, rose, white, or yellow flowers. These flowers are often dried and made into bouquets for winter use.

Thrifts are hardy and grow well in most garden soils. They usually reproduce by seed. Started in a greenhouse in early spring and then planted outside, they have flowers all summer.

Scientific classification. Thrifts belong to the leadwort family, Plumbaginaceae. Two common thrifts are *Armeria maritima* and *A. pseud-armeria.* Other common thrifts include *Limonium sinuatum* and *L. latifolium.*

Thrips are short, slender insects with sucking mouthparts. Most species feed on plants, but a few prey on other thrips. Adult thrips are usually less than 1 millimetre long. Some species have no wings. Others have two pairs of narrow, fringed wings and are good fliers. Thrips are serious plant pests.

Scientific classification. Thrips make up the order Thysanoptera.



Thrips

Throat is a popular term for the front part of the neck between the chin and the collar bone. The throat contains structures important in breathing and eating. It includes the pharynx, the larynx, part of the oesophagus, and part of the trachea. A sore throat results when any of these parts becomes inflamed.

When a person breathes, air enters the nose and travels through a passage called the *pharynx.* From the pharynx, it passes into the *larynx* (voice box), then through the *trachea* (windpipe), and into the lungs. Food, on its way from the mouth to the stomach, passes through the pharynx before it enters the *oesophagus,* the tube that leads to the stomach. Thus, part of the pharynx is a common passage for both food and air. The

The thrift is a hardy plant that thrives in most garden soils. The flowers are globe-shaped clusters made up of many tiny blossoms of white, pink, or other delicate colours.

routes of food and air cross one another in this passage, and it is possible for food to enter the wrong channel.

Normally, when a person swallows, two actions take place to block off the air passage. The *soft palate* presses against the back of the pharynx, closing the opening to the nose. At the same time, the larynx rises and is covered by the *epiglottis,* a leaf-shaped lid. These actions force the food into its own passage, the oesophagus, and muscular waves carry it to the stomach. When a person laughs or talks while swallowing, food may enter the larynx and choke the person until it is removed by coughing.

The largest muscle of the throat region is the *sternocleidomastoid.* It moves the head. This muscle looks like a cord in the side of the neck when the head is turned. It runs diagonally across each side of the neck from the breastbone to the skull behind the ear. Smaller muscles in the throat help in the actions of breathing, speaking, and swallowing.

Large arteries and veins pass through the neck. They carry blood to and away from the face, scalp, and brain. Unconsciousness may result from blockage of the arteries on each side of the trachea.

Related articles. See the Trans-Vision three-dimensional picture with **Human body.** See also:

Gargle
Larynx
Oesophagus
Pharynx
Tonsil
Trachea

Thrombosis. See **Blood** (Blood clotting); **Coronary thrombosis; Stroke.**

Throttle. See **Aeroplane** (Flying an aeroplane); **Carburettor.**

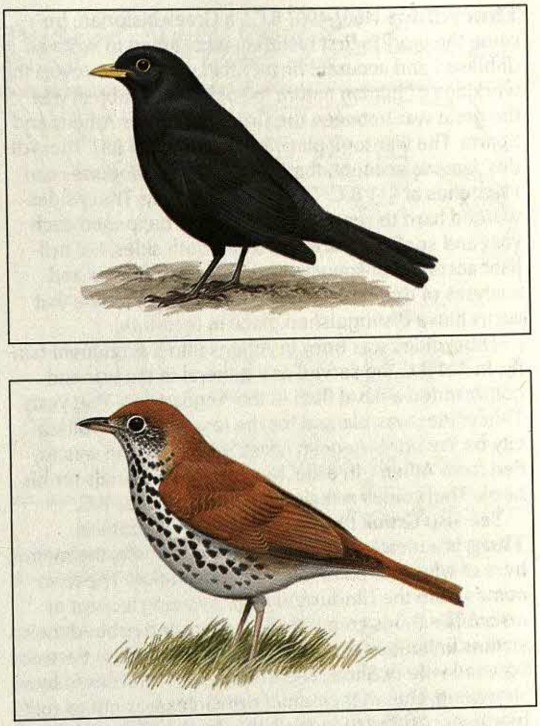
Thrush is the name of a group of songbirds found throughout the world. Many thrushes are plain, brown birds with pale, spotted underparts. Most thrushes are small or medium-sized birds between 10 and 35 centimetres long. Robins, wheatears, blackbirds, and nightingales all belong to the thrush group.

Thrushes nest in trees and bushes in parks, gardens, and wooded regions. The nests are often lined with mud. The *mistle thrush* of Europe and Asia grows up to 30 centimetres. It builds its nest in the fork of a tree and defends it against intruders by divebombing them.

Thrushes are often on the ground searching for worms, snails, and insects. They also eat fruit and berries. Thrushes of northern Europe, such as the *fieldfares* and *redwings,* migrate south and west in the winter.

The *song thrush* lives in Asia, Europe, and North Africa, and has also been introduced into New Zealand. It grows to between 20 and 25 centimetres long. It has a brown back and wings, a reddish-brown tail, and a spotted cream breast with small, black markings. It is famous for its beautiful song, often delivered from the top of a small tree. The song thrush likes to feed on snails. It breaks their shells by smashing them against a rock. The rock used for this purpose is called an "anvil," and is surrounded by shell fragments.

The *wood thrush* is a common bird of North America. It builds its nest in bushes or trees. The bird arranges a base of dead leaves and coarse grass, plasters the nest with mud, and lines it with roots or grasses. *White's thrush* is a ground-nesting thrush of Asia and Australia. It has a similar colour to the song thrush, but has a longer, stouter bill. There are distinct small, black, crescent-shaped markings on its breast and back.



Two members of the thrush group are the blackbird, *top above,* a common bird throughout Europe, and the North American wood thrush, *above.* Like the song thrush both birds have melodious songs. They were originally to be found in wooded areas but are now also familiar garden birds.

Scientific classification. Thrushes make up the subfamily Turdinae of the family Musciapidae. (Some authorities consider thrushes a separate family, Turdidae.) The mistle thrush is *Turdus viscivorus;* the fieldfare is *T. pilaris;* the redwing is *T. iliacus;* the song thrush is *T. philomelos;* the wood thrush is *Hylocichla mustelina;* White's thrush is *Zoothera dauma.*

Related articles in ***World Book*** include:

Bird
Blackbird
Bluebird
Flycatcher
Nightingale
Robin
Stonechat
Veery

Thrush is an infection with a yeastlike fungus, usually one known as *Candida albicans.* The infection usually occurs in moist parts of the body, for example in skin folds, the mouth, the respiratory tract, or the vagina. The medical name for this condition is *candidiasis.* The term thrush generally refers to infection of the mouth or vagina.

Candidiasis is the most common fungal infection in humans, occurring throughout the world. It is mostly seen in infants, or elderly people. It is quite common, too, in those whose immune systems have been suppressed, such as transplant recipients.

Oral thrush is the commonest form of candidiasis. It appears as sore white patches on the tongue and on the insides of the cheeks. Rarely, infection may spread throughout the body. Doctors treat thrush with antibiotics.

Thrust. See **Aeroplane** (Drag and thrust); **Jet propulsion; Space travel** (table: Space travel terms).

Thucydides (460?-400? B.C.), a Greek historian, became the world's first historian who aimed to write an unbiased and accurate history that would also reveal the workings of human nature in society. His subject was the great war between the Greek city-states Athens and Sparta. The war took place from 431 to 404 B.C. Thucydides' famous account, the *History of the Peloponnesian War,* ends at 411 B.C. To ensure accuracy, Thucydides worked hard to record events as they happened each year and spoke to participants on both sides. His brilliant accounts of speeches and his descriptions and analyses of dramatic actions are written in a style that earns him a distinguished place in literature.

Thucydides was born in Athens into a prominent family. In 424 B.C., he served as a general in the war and commanded a naval fleet in the Aegean Sea. That year, Thucydides was blamed for the loss of Amphipolis, a city on the north Aegean coast. As a result, he was exiled from Athens. In exile, he gathered materials for his book. Thucydides remained in exile until 404 B.C.

See also **Greek literature** (Historical literature).

Thug is a member of an old society in India, the members of which killed in the name of religion. The term comes from the Hindustani *thag,* meaning a *cheat* or *rascal.* The thugs committed murders and robbed their victims in honour of Kali, the Hindu goddess of destruction and wife of Shiva. The thugs always murdered by strangling. One of their chief principles was not to spill blood. According to legend, the thugs believed that Kali disposed of the bodies by devouring them. But one member of the society pried into Kali's actions. So the angry goddess condemned them to bury their victims in the future. The local Indian and British governments tried many times to stop *thuggee*—the practice of the thugs. In 1831, the British began a drive to end the practice, and it is now almost wiped out. Today, people commonly refer to robbers and other criminals as thugs.

Thulium is a chemical element with symbol Tm. It is one of the rare-earth elements. Its atomic number is 69. Its atomic weight is 168.934. The name comes from *Thule,* the Latin word for the northernmost part of the inhabitable world.

The Swedish scientist Per Cleve discovered thulium in 1879. Thulium occurs with other rare earths in the minerals gadolinite, euxenite, xenotime, and others. Thulium is best separated from the other rare earths by ion-exchange processes or by solvent extraction. It melts at 1545° C, and boils at 1950° C. It has a density of 9.318 grams per cubic centimetre at 25° C. Portable X-ray units use radioactive thulium. Such units require no electrical equipment, and they need to be recharged with thulium only once every few months.

See also **Element, Chemical** (tables); **Rare earth.**

Thumb. See **Hand.**

Thumb, Tom. See **Stratton, Charles S.**

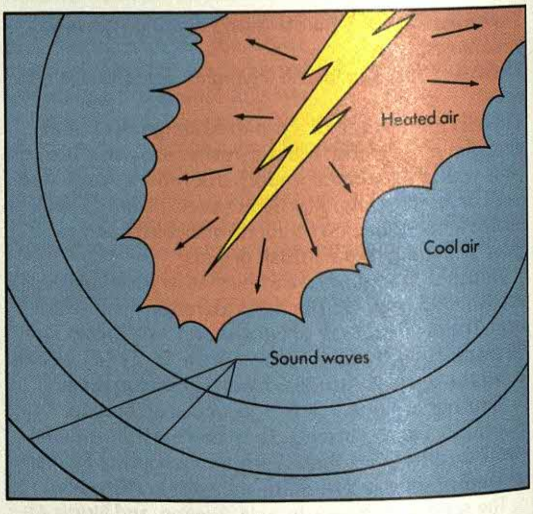
Thumboo, Edwin (1933-), a Singapore writer, critic, and academic, became professor of English at the National University of Singapore in 1979. He was highly acclaimed for his poetry. His collection of poems *Gods Can Die* (1977) received the Singapore National Book Development Council award for poetry in 1978. In 1979, he was given the Southeast Asia Writers' Award for poetry. In 1987, he received the Asean (Association of Southeast Asian Nations) Award for distinguished achievements in literary works. His published anthologies include *The Flowering Tree* (1970), *Seven Poets* (1973), *The Second Tongue* (1976), *Rub of Earth* (1956), and *Ulysses by the Merlion* (1979).

Edwin Thumboo was born in Singapore. He was educated at the Victoria School and the University of Malaya in Singapore.

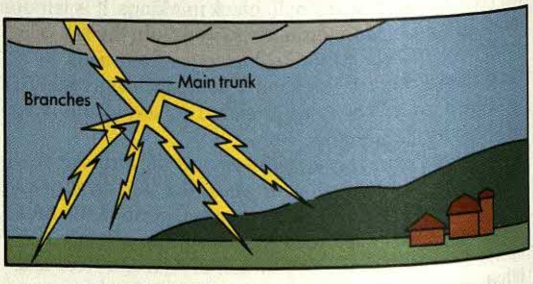
Thunder. Prehistoric people thought that thunder was the sound of the gods roaring in anger when they were displeased with the people of the earth. Today, scientists know that thunder is caused by the violent expansion of air that has been heated by lightning.

Air is heated instantly when an electrical charge of lightning passes through it. The heat causes the molecules of air to expand, or fly out, in all directions. As the molecules seek more room, they collide violently with layers of cool air, and set up a great air wave that has the sound of thunder.

Thunder has many different sounds. The deep, rumbling roar of thunder is caused by the air wave from the lightning trunk that is farthest away from an observer. The sharp crackle of thunder is set up when the large trunk of lightning forks out into many branches. The loud crash of thunder is caused by a main trunk of lightning that is near an observer. The sound of thunder



Thunder is the sound caused by lightning. Lightning heats the nearby air, causing it to expand. The expanding hot air collides with cool air, creating sound waves that we hear as thunder.



Different sounds of thunder come from different parts of a bolt of lightning. The main trunk of lightning causes the loudest crash. The branches produce the sharp, crackling sound.

reaches us after we have seen the lightning. That is because light travels at 299,792 kilometres per second, while sound travels at a rate of only about 335 metres per second. The number of seconds between seeing the lightning flash and hearing the thunder, divided by three, yields the distance of the lightning from the observer in kilometres.

See also **Lightning; Jupiter; Thor; Zeus.**

Thunderbolt, Captain, was a bushranger who operated mainly in the New England district of New South Wales, Australia, between 1864 and 1870. He became known as an enthusiastic horseman, willing to ride far in order to steal a good racehorse.

Captain Thunderbolt

Many people believe that Captain Thunderbolt's real name was Frederick Ward. Ward was born at Windsor, in New South Wales. In 1860, he was imprisoned on Cockatoo Island, in Sydney, for horse stealing. In 1863, his part-Aboriginal wife helped him to escape, and he became a bushranger. For seven years, he eluded capture, but his exploits became increasingly reckless. On May 25, 1870, he robbed a hawker, who reported the incident to police. Two constables set off after Thunderbolt. One of them shot the bushranger's large, grey horse and shouted to Thunderbolt to surrender. The bushranger waved his gun and said, "I'll die first." The constable then shot him and went for help. Thunderbolt crawled into some bushes and died. When the police returned, they discovered that his gun had no bullets. He was buried at Uralla, Australia.

Some people believe that Captain Thunderbolt was Frederick Britten, an inmate who escaped with Frederick Ward. Britten was also born in Windsor.

Thunderstorm. See **Cloud** (Storms); **Hail.**

Thuraisingham, Dato Sir Clough (1898-1979), a politician and a prominent member of the Tamil community in Malaya, founded the Ceylon Federation of Malaya. Clough Thuraisingham was born in Taiping, in the state of Perak. He was educated in Colombo, Ceylon (now Sri Lanka). Later, he studied in the United Kingdom at Cambridge University and the Middle Temple in London.

From 1934 to 1941, Thuraisingham managed the family rubber estates in Johor and Perak. He became a member of the Malayan Advisory Council in 1946. There, he upheld the interests of the Ceylon Tamil community and the Communities Liaison Committee. In 1951, he was put in charge of a programme to expand and improve schools and colleges throughout the country, as Malaya prepared for independence from British rule.

Thurber, James (1894-1961), was a celebrated American humorist. He became famous both for his comic writings and his cartoonlike drawings.

Thurber's works describe the anxieties of the average individual in modern society. He wrote chiefly about oversensitive, dissatisfied men who feel trapped by the complications of the modern world. The men in his stories are frustrated by their domineering wives and rebellious children. They often fear such machines as cars and dread the pressures of their jobs. They try to escape from their problems through alcohol or daydreams. Thurber's short story "The Secret Life of Walter Mitty," for example, portrays a man who finds relief from his nagging wife through daydreams. In his daydreams, Mitty always plays the fearless hero.

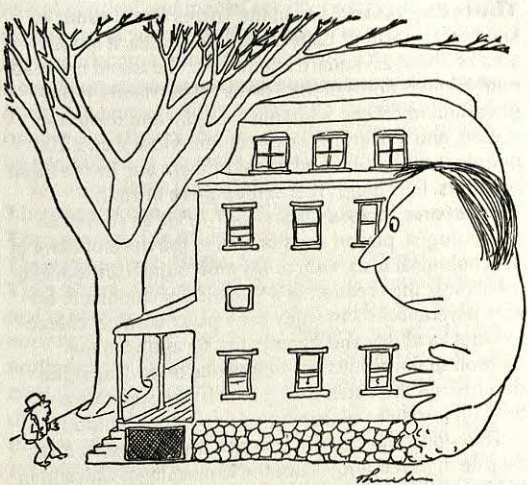


Illustration by the author from *The Thurber Carnival* by James Thurber, published by Harper and Row.

A Thurber cartoon illustrates one of his favourite subjects, a timid middle-aged man married to a domineering woman.

Many of Thurber's works include cartoons of frightened men, menacing women, wicked children, and sad dogs. Many of his stories, essays, and drawings appear in such collections as *The Middle-Aged Man on the Flying Trapeze* (1935) and *The Thurber Carnival* (1945). He wrote his first book, *Is Sex Necessary?* (1929), with E. B. White and co-authored a play, *The Male Animal* (1940), with Elliott Nugent. Thurber also wrote an autobiography, *My Life and Hard Times* (1933). Much of his work first appeared in *The New Yorker* magazine. He wrote about Harold Ross, the first editor of *The New Yorker,* in *The Years with Ross* (1959). James Grover Thurber was born in Columbus, Ohio, U.S.A. He was blind for the last 15 years of his life.

Thurrock (pop. 124,300) is a local government district in Essex, England. Thurrock district includes the towns of Grays, Purfleet, and Tilbury, and a number of attractive villages set in beautiful countryside. Grays, more properly called Grays Thurrock, is the administrative centre and main shopping area for the district. Thurrock's industries include electronics, engineering, oil refining, warehousing, and margarine, shoe, and soft toy production. Tilbury lies on the north bank of the River Thames. Its docks form the Port of London. Near Tilbury is the Thames-side community of Stanford le Hope. South Ockendon is a suburb of Grays. See also **Essex.**

Thursday is the fifth day of the week. The ancient Norsemen considered the day sacred to Thor, the Teutonic god of thunder. The name means *Thor's day.* This is probably a translation of the Latin *dies Jovis,* meaning *Jove's day,* for Jove, or Jupiter, the Roman god of thunder. See also **Thor; Week.**

Thursday Island lies in the Torres Strait, about 40 kilometres north of Cape York, in Australia. It has an area of about 2.5 square kilometres. The island is the administrative centre of the Torres Strait Islands. It has government offices, a hospital, a radio and telegraph station, and a pearl research station. More than 2,200 people live on the island. Most of them are Torres Strait Islanders. Europeans first settled there in 1877.

Thurstone, Louis Leon (1887-1955), an American psychologist, played a major role in the development of psychological tests. One of his most significant achievements was the creation of a statistical technique to enable psychologists to study such psychological characteristics as ability and personality. By applying the method to the results of intelligence tests, Thurstone determined that intelligence consists of separate abilities, among them reasoning and numerical aptitude.

Thurstone was born in Chicago. He received a Ph.D. degree in psychology from the University of Chicago in 1917.

Thutmose III (reigned *c.* 1490-1436 B.C.), ranks among the greatest of all the kings of ancient Egypt. He is also known as Thothmes III. Thutmose succeeded his father, Thutmose II, but was kept in the background by his stepmother, Queen Hatshepsut. After Hatshepsut died, Thutmose III ordered her name erased from monuments and statues.

Thutmose III became a brilliant general and also a capable administrator. By his well-planned campaigns, mainly in Palestine and Syria, he expanded Egypt's imperial boundaries. He greatly enlarged the vast temple at Karnak. Its walls still bear the hieroglyphic records of his wars, long lists of captured cities in Asia and Africa, and pictures of plants and animals collected on his campaigns. Thutmose erected granite *obelisks* (giant stone pillars) in Karnak and Heliopolis. The two he erected at Heliopolis are now known as *Cleopatra's Needles.* One stands on the Thames Embankment in London, and the other in Central Park in New York City.

See also **Egypt, Ancient** (History: The New Kingdom).

Thylacine. See **Tasmanian tiger.**

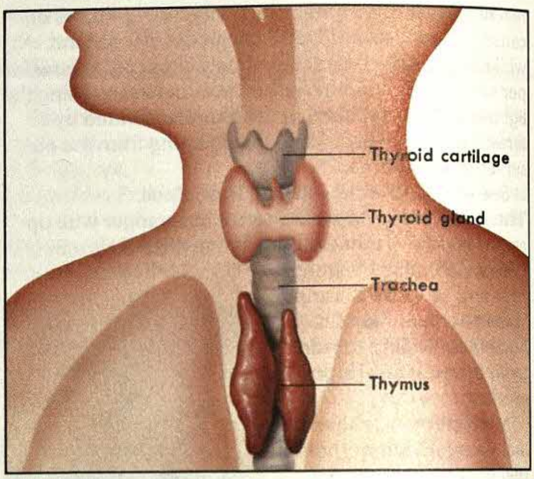
Thyme is the name of a group of fragrant, shrubby mint plants native to the Mediterranean region. The ancient Greeks used thyme as temple incense. Thyme has a bitter flavour that makes it a popular seasoning for meats and sauces. Thymol, an antiseptic drug, is prepared from oil extracted from thyme. This drug is used in mouthwashes and cough remedies.

The *common thyme,* also called *garden thyme,* grows to a height of 15 to 20 centimetres. It has hairy, upright stems with many pairs of small elliptical leaves. The tips of the branches are encircled by clusters of tiny flowers that range in colour from whitish to lilac. Thyme grows well in dry, nutrient-poor soil.

Scientific classification. Thyme belongs to the mint family, Labiatae (Lamiaceae). Common or garden thyme is *Thymus vulgaris.*

Thymus is a flat, pinkish-grey organ that plays an important part in the immune system of the human body. It is located high in the chest cavity behind the breastbone and extends into the lower neck below the thyroid gland.

The thymus aids in the development of white blood cells called *lymphocytes,* which help the body fight disease. There are two kinds of lymphocytes, both of which are formed from cells in the bone marrow. Some lymphocytes, called *B cells,* probably mature in the bone marrow itself (see **Immune system**). The *B* stands for *bone marrow derived.* The other lymphocytes travel to the thymus, where they are changed into *T cells.* The *T* stands for *thymus derived.* The thymus produces a substance called *thymosin,* which scientists believe plays an important part in the change into T cells.



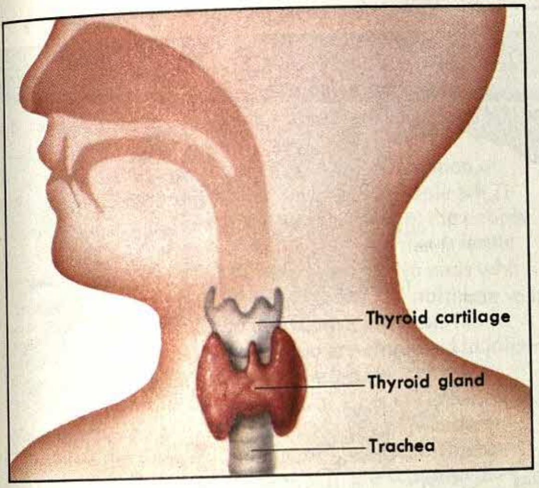
The thymus is in the upper chest, behind the breastbone. It aids in the formation of white blood cells called *lymphocytes,* which protect the body from disease.

The T cells leave the thymus and inhabit the blood, lymph nodes, and spleen. There, they attack bacteria, cancer cells, fungi, viruses, and other harmful organisms. T cells are sometimes called "killer cells" because of their ability to find and destroy such organisms. T cells also attack organs that have been transplanted from one person to another. This is called *transplant rejection.* Powerful drugs are needed to prevent T cells from destroying the transplanted organ.

When a person is born, the thymus weighs about 15 grams. By the age of 12, it has grown to about twice its original size. At that time, the lymph nodes and the spleen take over the task of producing lymphocytes. The thymus then begins to shrink and produces fewer T cells. By adulthood, the organ has shrunk so much that it may be hard to distinguish from the fatty tissue that surrounds it. Babies born without a thymus may fail to develop a normal immune system.

The thymus may be removed to treat *myasthenia gravis,* a disease that is characterized by severe muscle weakness. For reasons not completely understood, removal of the thymus helps many patients with this disease become stronger. Loss of the thymus has no noticeable effect on the immune system. See **Myasthenia gravis.**

Thyroid gland is an *endocrine* (hormone-producing) gland located in the front of the neck. It has two *lobes* (parts), one on each side of the *trachea* (windpipe). The lobes are connected by a thin band of tissue. A network of blood vessels surrounds the gland. The thyroid takes iodine from the blood and uses it to make the active hormones *thyroxine,* also called *tetraiodothyronine,* and



The thyroid gland is in the neck. This gland produces and stores a hormone called *thyroxine,* which is essential for mental development and physical growth.

triiodothyronine. An inactive form of thyroid hormones is stored inside the lobes in chambers called *follicles.*

Thyroid hormones control the body's *cell metabolism.* When thyroid hormones are released into the bloodstream, cells increase the rate at which they convert oxygen and nutrients into energy and heat for the body's use. During a child's development into adulthood, thyroid hormones stimulate an increase in growth rate. Release of thyroid hormones also stimulates mental activity and increases the activity of the other hormone-producing glands.

Thyroxine and triiodothyronine are released into the bloodstream in response to such conditions as stress, pregnancy, and low levels of thyroid hormones in the blood. These conditions activate a hormone in the pituitary gland called *thyroid-stimulating hormone* (TSH). TSH regulates the thyroid's production of hormones.

The thyroid gland produces another hormone, *calcitonin,* in response to high levels of calcium in the blood. Calcitonin causes the kidneys to discharge more calcium into the urine, and it raises the amount of calcium stored in the bones.

Underactive thyroid, called *hypothyroidism,* is a defect that results in a reduced production of thyroid hormones. This deficiency causes an overall decrease in both physical and mental activity. Symptoms appear in almost every organ system of the body. The skin becomes dry and puffy. Hair thins and becomes brittle. Slow speech, slow reflexes, poor memory, constipation, and fatigue can all result from hypothyroidism. In adults, hypothyroidism is called *myxoedema.* If the condition goes untreated in infants, it causes physical and mental retardation (see **Cretinism**). When hypothyroidism is detected in a newborn child, thyroid hormones can be replaced or supplemented by drugs to prevent retardation. A myxoedemic adult can also be treated with drugs.

Overactive thyroid, called *hyperthyroidism,* results in an overproduction of thyroid hormones. An excess of thyroid hormones in the blood causes an increase in the rate of most biological reactions. This leads to a higher rate of physical and mental activity. Symptoms of hyperthyroidism include sweating, excessive nervousness, insomnia, diarrhoea, and *exophthalmos.* Exophthalmos is a condition in which the eyes bulge abnormally. Treatment of hyperthyroidism sometimes involves surgery to remove a portion of the thyroid gland. Drugs can also be prescribed to decrease thyroid production.

See also **Gland; Goitre; Hormone.**

Thysanoptera. See **Insect** (table); **Thrips.**

Thysanura. See **Insect** (table).

Tiahuanaco Indians. See **Bolivia** (History).

Tian Shan, also spelled *Tien Shan,* is a mountain system in central Asia. It runs for over 2,400 kilometres northeast from the Pamirs (see **Pamirs**). It extends into northwestern China. Tian Shan means *Heavenly Mountains.* The system is the highest mountain system north of Tibet. Pobeda Peak, the highest peak, rises 7,439 metres above sea level. Rivers flow north from Tian Shan into Kyrgyzstan and Kazakhstan, and south into China. The system includes some of the world's largest glaciers. Roads follow passes through Tian Shan. For location, see **Asia** (terrain map).

Tianjin (pop. 5,300,000) is a trading centre in northern China. Its name is also spelled *Tientsin* or *T'ien-chin.* In 1860, the Chinese opened the city and its port to foreign trade. Nine countries received *concessions* (tracts of land). These have now all been given back to China.

Tianjin is 137 kilometres southeast of Beijing, near the mouth of the winding Hai River (see **China** [political map]). Chinese emperors did not allow foreign merchants to live in Beijing, the rich capital. So traders who wanted to sell goods to Beijing settled in Tianjin. As a result, Tianjin became an important centre of foreign trade. Railways connect Tianjin with Beijing, Nanjing, Shanghai, and the cities of Manchuria. Tianjin lies at the northern end of the Grand Canal, a water route that leads to southern China.

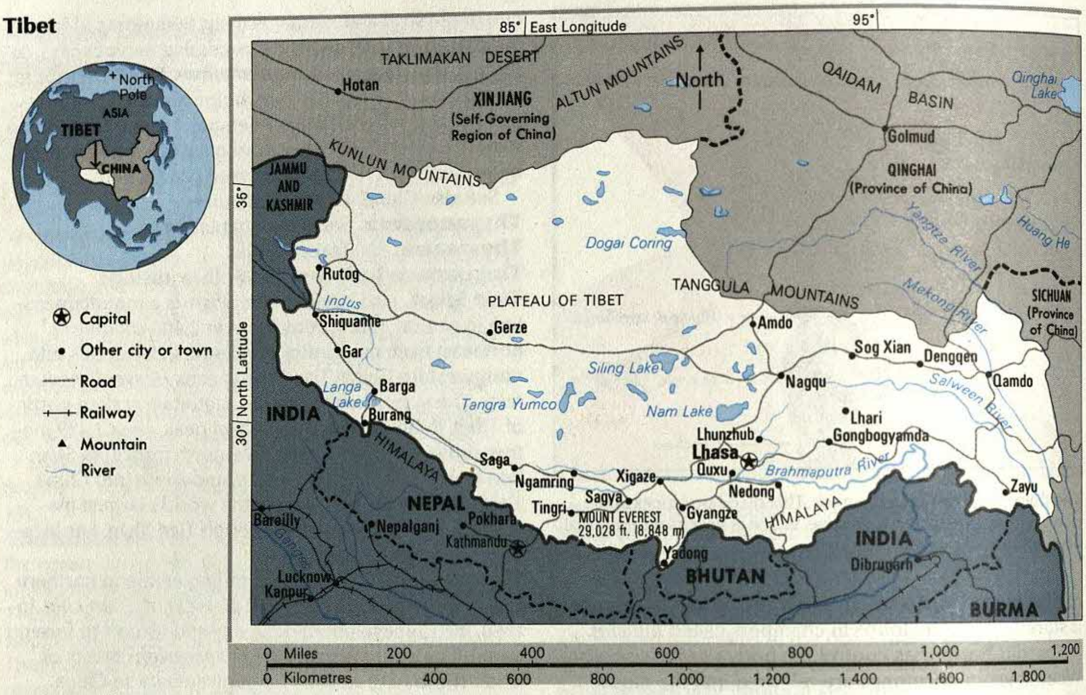
Tianjin is the chief port for Beijing and a centre for foreign and domestic trade for northeastern China. Since the 1970's, the production of goods in Tianjin has expanded from textiles and handicrafts to a wide range of consumer goods and industrial products. For example, Tianjin has become an important centre for petrochemical products since the discovery of offshore oil fields nearby. Much new construction has taken place in the city since the 1970's. Tianjin has more than 25 universities and technical schools.

Fighting between Japan and China in 1937 badly damaged Tianjin. Japan then gained control of the city and held it until World War II ended in 1945. In 1976, an earthquake struck Tianjin, Beijing, and the area around the cities. About 240,000 people died in the disaster and property damage was extensive.

Tiber River is the third longest river in Italy. Only the Po and the Adige are longer. The Tiber rises in the Apennine Mountains in central Italy, 1,268 metres above sea level. The river flows for about 390 kilometres, first through the Sabine Mountains, a range of the Apennines, then through Rome and into the Tyrrhenian Sea (see **Italy** [terrain map]). It flows into the sea through branches at Ostia and Fiumicino. The Tiber has often overflowed its banks. Flood embankments have been built at Rome.

Tiberias, Lake. See **Galilee,** Sea of.

Tibet



Tiberius (42 B.C.-A.D. 37) was the emperor of Rome during the life of Jesus Christ. His full name was Tiberius Claudius Nero. The second emperor of Rome, Tiberius succeeded the emperor Augustus, who was Tiberius' stepfather and adoptive father.

Tiberius became a successful army commander for Augustus. The emperor forced Tiberius to divorce his wife and marry the emperor's daughter, Julia. But Tiberius and Julia were unhappy, and he left her and went to live on the island of Rhodes. By A.D. 4, both of Augustus' grandsons and Tiberius' brother, Drusus Claudius, had died. Augustus then recalled Tiberius to Rome and made Tiberius his heir and successor. When Augustus died in A.D. 14, Tiberius became emperor.

Tiberius was a fine administrator. He carefully supervised tax collections and balanced the budget. He chose efficient governors for the provinces of Rome and maintained friendly relations with the neighbouring kingdoms of Parthia and Armenia.

When Germanicus, Tiberius' nephew and possible successor, died, his widow accused Tiberius of causing his death. Because of difficulties with the Senate, Tiberius retired to the island of Capri. He gave great power to Sejanus, the *prefect* (commander) of the Praetorian Guard (see **Praetorian Guard**).

Tiberius became unpopular during his last years because of his poor relations with the Senate and because he failed to end widespread prosecutions for treason. But he left a peaceful and prosperous empire to his heir Caligula, a descendant of Augustus (see **Caligula**).

Tibet is a land in south-central Asia. It is often called the *Roof of the World.* Its snow-covered mountains and a windswept plateau are the highest in the world. The world's highest mountain, Mount Everest, towers along the southern mountain wall of Tibet. Ka-erh, in western Tibet, is believed to be the highest town in the world. It is more than 4,570 metres above sea level. Valley bottoms in Tibet are higher than the mountains of most countries. Lhasa is Tibet's capital.

Tibet has been a part of China since the 1950's. However, for many years Tibet was an independent or semi-independent state. Although it carried on some trade with other lands, its mountain ranges generally isolated it from outside peoples. The Tibetans are sometimes called the *hermit people.* Tibet was traditionally a *theocracy* (religious kingdom). Buddhist monks had a strong voice in the rule of Tibet before China took control.

Land. Tibet has an area of 1,221,600 square kilometres. A high, cold plateau called the Plateau of Tibet covers much of the land. High mountain walls border the plateau. Along the southern end of the plateau, the snowy Himalaya rises higher than any other mountain chain in the world. Mount Everest (8,848 metres above sea level) is in the Himalaya. In the north, many peaks of the Kunlun range rise more than 6,000 metres. Tibet has an average elevation of 4,880 metres.

Large parts of Tibet are wastelands of gravel, rock, and sand. Most of the land cannot be farmed because of poor soil and a cold climate. But there are some fertile valleys and other areas suitable for farming. Tibet also has areas of grasslands and forests. More than 5,000 different kinds of plants grow in Tibet. Tibet's wild animals include deer, gazelles, tigers, bears, monkeys, pandas, and wild horses. Tibet has hundreds of lakes and streams, but many of them have barren shores and a high salt content. Some of the great rivers of Asia begin in the mountains of Tibet. These include the Brahmaputra, Indus, Mekong, Salween, and Yangtze rivers.

Climate. Much of Tibet receives less than 25 centimetres of rain annually. The Himalaya shuts out moisture-bearing winds from India. Sudden blizzards and snowstorms are common. Violent winds sweep Tibet in all seasons. January temperatures average −4 °C. July temperatures average 14 °C.

People and their work. Tibet has a population of about 2 million. About 96 per cent of the people are Tibetans. Most of the rest are Chinese. Most of the people live in southern Tibet, where there is land that is fertile enough for farming and raising livestock. Nomads who raise sheep and *yaks* (hairy oxen) live in the northern grasslands. About 106,000 people live in Lhasa, Tibet's largest city. Many of these people are employed in jobs in government, light industry, or tourism.

The main traditional language of Tibet is Tibetan. All Tibetans speak Tibetan at home. However, Mandarin Chinese is the official language of Tibet. Both Tibetan and Mandarin Chinese are taught in the schools. All government documents are written in both languages.

Before China seized Tibet, the nobility and monks called *lamas* owned the farmland and governed the country. Most farmers were serfs. The serfs were not free to leave the land, and they had to give much of what they produced to the landowners. China, a Communist country, broke up the large estates belonging to the monks and the nobility and distributed them among peasant farmers.

Tibetan homes have stone or brick walls and flat roofs. Few houses have more than two floors. But houses built for the wealthy have three or four floors. The ground floor is used to house animals.

Barley is Tibet's chief crop, and barley flour is the main food. Tibetans mix barley flour with tea and butter. Milk and cheese are also important parts of the diet. Chinese tea is the chief beverage. Tibetans flavour the tea with salt, soda, and yak butter.

The yak serves many purposes in Tibet. It provides cloth, meat, milk, and transportation. It is also used as a beast of burden. Its hair is used for tents, and its hide for shoe leather and boats.

Typical clothing of Tibetan men and women includes a long robe with long sleeves and a high collar. Wealthy people wear silk robes. Wool, felt, and sheepskin are common clothing materials for the cold weather. Lighter garments are made of hemp and cotton.

Cloth weaving and carpet making are household industries in Tibet. Wool is a major export. Other traditional exports include furs, mules, musk, and ponies.

Religion and culture. Tibetans are intensely religious. People turn prayer wheels and recite prayers on the streets. Religious rites are an important part of everyday life. Festivals are religious in character. Long pilgrimages to important temples in Lhasa or Xigaze are popular.

Tibet's religion is a branch of Buddhism called *Lamaism.* The religion recognizes two Grand Lamas. The Dalai (High) Lama is regarded as the ruler of Tibet and its highest spiritual ruler. The Panchen Lama is regarded as a leading spiritual authority. Tibetans regard both Grand Lamas as Buddha, born again. When the Dalai or Panchen Lama dies, his spirit is thought to enter the body of a baby boy. Monks search the country for a boy who was born about the same time as the death of the lama. The boy thus selected becomes the lama's successor. The Chinese ended the authority of the Dalai Lama and Panchen Lama after they took control of Tibet.

Don Weiss

A public square in Lhasa, Tibet's capital and largest city, is a gathering place for people. Two women from the Kham region of eastern Tibet, *centre,* wear traditional clothing.

There are several different sects of Lamaism. The chief sect is the Yellow Hat, headed by the Dalai Lama, who lives in exile in India.

In the past, large numbers of Tibetan men became monks and every town and valley had a monastery, called a *lamasery.* Before the Chinese take-over, as many as 20 per cent of all Tibetan males were monks. Many Tibetans became monks because they were sent to the monasteries as children by poor parents who could not pay their debts or taxes. Others went because the monasteries were the only places that provided an education.

During the 1960's and 1970's, the Chinese Communists closed or destroyed most of the monasteries in Tibet. As a result, the religious emphasis of life in Tibet decreased a great deal. During the 1980's, some of the monasteries were allowed to reopen and recruit new monks.

Today, Tibet has far fewer monasteries than it had in the past, and only a few thousand males are monks. Many monks engage in agriculture and handicrafts. The monasteries are centres of education, art, and public worship. Tibetan art reflects Chinese and Indian influences, and presents Buddhist themes.

Cities. Lhasa is the political and religious centre of Tibet. The Potala Palace is the most impressive landmark in Lhasa. It is a grand, castlelike structure with gold roofs and more than 1,000 rooms. Formerly a residence of the Dalai Lama and other monks, it now houses a museum that has many art treasures. Other cities include Gyangze, Xigaze, and Yadong.

History and government. During the A.D. 600's, Tibet became a powerful kingdom. Buddhism and writing were introduced from India, and Lhasa was founded. The Dalai Lama became the ruler of Tibet in the 1600's.

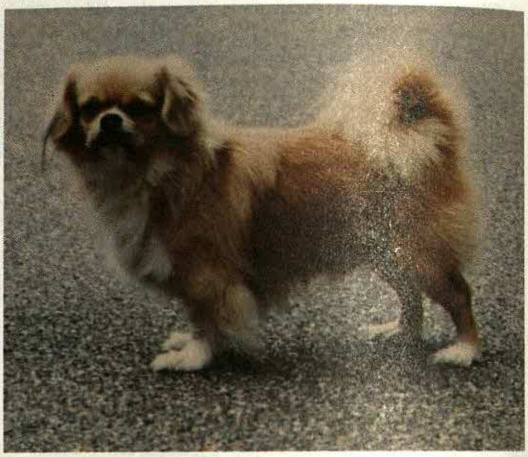
In the early 1700's, Tibet fell under the control of China. A British mission arrived in Lhasa in 1904. The British and Tibetans signed a treaty, setting up trading posts in Tibet.

Tibet remained in Chinese hands until 1911, when Tibetans forced out the Chinese troops stationed there. Even after 1911, China claimed Tibet as an area within the Chinese domain. In the 1920's, rivalry grew between the Dalai and Panchen lamas over political affairs. The Panchen Lama fled to China with his court. He remained there until his death in 1937. A new Panchen Lama was enthroned in China in 1944, but he was not officially recognized in Tibet until 1949. The Dalai Lama died in 1933. According to custom, a boy was chosen as his successor. The successor, a peasant boy, was officially installed as Dalai Lama in 1940.

Communists gained control of China's government in 1949. In 1950, Chinese forces entered Tibet. In 1951, Tibetan representatives signed an agreement with China in which Tibet surrendered its sovereignty to the Chinese government but kept its right to regional self-government. The agreement promised no immediate change in the political system of Tibet and guaranteed the Tibetans freedom of religious belief. Committees made up of both Tibetans and Chinese were established as local governments in various parts of the country. In 1956, the Preparatory Committee for the Tibetan Autonomous Region was formed with the Dalai Lama as chairman, and a Chinese general and the Panchen Lama as two of the vice chairmen. This committee was founded to establish Tibet as an *autonomous* (self-governing) region.

But also in 1956, China began tightening its control of Tibet. The Dalai Lama fled to India in 1959. The Panchen Lama became head of the Preparatory Committee. By 1965, when Tibet officially became an autonomous region, the large estates of landlords and monks had been broken up. Peasants were required to sell a fixed amount of grain to the government and were forced to grow wheat rather than barley to feed the Chinese soldiers. The Chinese government took control of the radio stations, newspapers, banks, and shops that sold food. Chinese people took over a majority of such jobs as local government administrators and teachers. Tibetans faced discrimination by Chinese soldiers and settlers. Many Tibetans believed their lives were getting more difficult rather than better. In the 1950's and 1960's, Tibetans staged riots against Chinese rule.

In the 1980's, the Chinese government adopted a more liberal policy toward Tibet. Some religious shrines were opened to worshippers, as were some surviving monasteries. Farmers were again allowed to decide which crops to grow and to sell them as they chose. But in the late 1980's, riots by Tibetans against Chinese rule broke out in the Lhasa area. China then sent troops to Tibet to restore order. Many observers believe the riots were protests against the slow pace of reform and the discrimination by Chinese against Tibetans. In 1989, the Panchen Lama died. He had supported many of China's policies in Tibet and favoured unity with China. While living in exile, the Dalai Lama worked to end China's domination of Tibet through nonviolent means. He won the 1989 Nobel Peace Prize for his consistent opposition to the use of violence in his campaign.



A Tibetan spaniel has a thick coat and a curly tail.

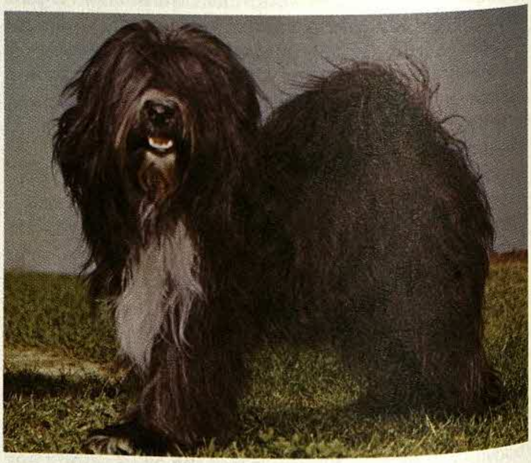
Related articles in ***World Book*** include:

Asia (Way of life in Central Asia)
Brahmaputra River
Himalaya
Lamaism
Lhasa
Mekong River
Mount Everest
Painting (Indian painting; picture: Raktayamari)
Tang dynasty (The middle years)
Yak

Tibetan spaniel is a breed of dog that originated in Tibet hundreds of years ago. Buddhist monks kept these dogs as pets and as watchdogs for monasteries. The dogs were also companions to Tibet's rulers. Visitors to Tibet first brought the breed to Europe in the 1800's. Tibetan spaniels are not actually spaniels.

The thick, silky coat of a Tibetan spaniel lies flat against the body. The coat may be almost any colour or combination of colours. The bushy tail curls over the back, and the shoulders are covered with a *ruff* (frill) slightly longer than the rest of the fur. The dogs stand from 24 to 28 centimetres high at the shoulder and normally weigh between 4.5 and 5.5 kilograms.

Tibetan terrier is a breed of dog that originated in Tibet, where Buddhist monks raised it in monasteries.



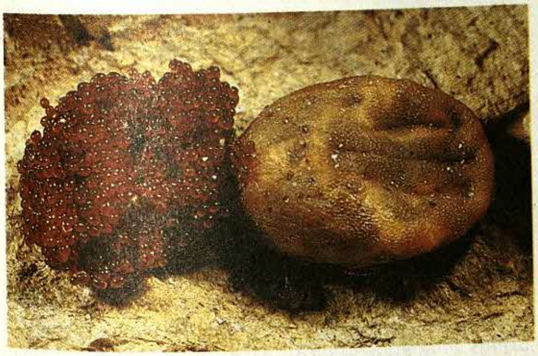
The Tibetan terrier has a heavy coat of long hair.

The Tibetans once believed these dogs were holy, and monks gave them to important people for good luck.

Tibetan terriers stand from about 35 to 40 centimetres high and weigh between 8 and 13.6 kilograms. They resemble miniature Old English sheepdogs. They have a thick, shaggy coat that may be black, cream, gold, grey, or white, or a combination of those colours. The Tibetan terrier has a fluffy tail that curls over the dog's back.

Tic is a term used to describe repetitive, brief, rapid, involuntary movements of various muscle groups. Tics occur at random intervals. Examples of simple tics include shoulder shrugging, eye blinking, facial twitching, head and neck jerking, kicking and bending movements of the waist. Tics are most commonly seen in the face, head, and neck. See also **Neuralgia; Tourette syndrome.**

Tick is the name of a tiny, bloodsucking animal that is related to mites, spiders, and scorpions. The tick is oval in shape. It is a parasite, which means that it lives on other animals. Ticks and mites cause various diseases in human beings and in domestic animals. Ticks often carry certain disease germs in their bodies and transfer these germs to the blood of their victims. Sometimes the bites of ticks are poisonous. Cases of paralysis are known to have followed their attacks. However, such effects are not common, and the victim usually recovers rapidly once the tick is removed.



A female tick may lay up to 18,000 eggs at one time. After hatching, the larvae attach themselves to passing animals.

The sheep tick sucks the blood of animals and people. Its body becomes swollen with blood after it has eaten, *above.*

Ticks and mites look much alike in body structure, but ticks are larger. Ticks look somewhat like insects but are not. Most kinds of ticks can be seen without a magnifying glass. They live only on animal fluids. But some mites feed on plant juices and tissues, on decaying matter, and on small insects and other mites.

The bodies of ticks seem to be all in one piece. But some have a groove behind the head. The head of a tick is a movable part at the front end of the body. Ticks draw blood through a beak. Other body parts help ticks cling tightly to their host. Adult ticks have eight legs which stick out on the sides like those of a crab.

The tick lays eggs in dead leaves or other ground rubbish. The eggs hatch into flat, six-legged larvae. These larvae wait on grass stalks and shrubs for passing animals. Once attached, they gorge on the blood of these animals and swell up. Then, they cease to eat and begin to *moult* (shed their outer covering). After this, they become eight-legged nymphs. The nymphs resume feeding, moult again, and then are adults.

There are about 800 different kinds of ticks. While some have special names, such as *chicken, cattle, dog,* or *sheep* tick, few of them are limited to one kind of host animal. Many ticks that attack animals also attack human beings.

European ticks include the sheep tick, which also lives on dogs or cattle. Australia has almost 60 kinds of ticks. The paralysis tick, or dog tick, of eastern Australia is one of the best known. It is common in coastal areas. The adult female dog tick has a greyish body up to one centimetre long. Its bite can be dangerous to dogs and other pets. It can also harm small children. Its poisonous saliva has caused human deaths. However, the development of an *antivenin* (antidote) has now largely eliminated this threat.

The American dog tick and the Rocky Mountain wood tick transmit *Rocky Mountain spotted fever* to humans. The disease causes a few deaths each year in the United States. Deer ticks transmit *Lyme disease* to humans. If untreated, this disease can lead to chronic arthritis and heart and nerve disorders.

To remove a tick that has attached itself to the skin, use fine-tipped tweezers to grasp the tick's mouthparts as close to the skin as possible. Grasping the body may cause the head or mouthparts to break off and cause infection. Apply a firm, steady pull to remove the tick. Do not try to remove a tick by burning it off, or by coating it with nail polish, oil, or petroleum jelly. Avoid handling the tick with bare hands if the hands have any cuts or scratches. Wash the hands after removing the tick. Apply antiseptic to the wound to avoid infection. Save the tick for identification.

Scientific classification. Ticks belong to the class of arachnids. Together with mites, they make up the order Acarina. The sheep tick is *Lxodes ricinus.* The paralysis tick is *L. holocyclus.* The American dog tick is *Dermacentor variabilis.* The Rocky Mountain wood tick is *D. andersoni.*

See also **Cattle tick; Mite; Tick fever.**

Tick fever is a name for several diseases carried by the bite of ticks. They include Colorado tick fever, relapsing fever, Rocky Mountain spotted fever, and Texas fever. Texas fever is a disease of cattle. These diseases are infections by different microbes, which enter the body through the tick bite. See also **Relapsing fever.**

Ticking is a strong fabric used chiefly to cover mattresses and pillows. It is woven closely of stout yarn so that cotton felt, feathers, curled horsehair, and other fillings for bedding cannot pass through. Ticking may be made of cotton, synthetic fibres, or a blend of cotton and synthetic fibres in a twill, herringbone twill, or jacquard weave. See **Twill.**

Ticonderoga, Battle of. See **Fort Ticonderoga.**

Tidal wave is a destructive wave that sweeps in from the sea like a huge tide. However, tidal waves are not related to true tides. Instead, they are caused by undersea earth movements called *seaquakes* or by hurricanes, cyclones, or other large storms at sea.

Tidal waves caused by seaquakes are called *seismic sea waves.* They also are known as *tsunamis,* a name given them by the Japanese. Scientists using seismographs can accurately predict when a tsunami will arrive at a given seacoast. For example, they know that a seaquake off the Aleutians may cause a tsunami that will hit the coast of Hawaii. If seismographs in Hawaii show that a seaquake has occurred off the Aleutians, the forecaster calculates the number of minutes that it took for the earth tremor to reach Hawaii. It will take about the same number of hours for the tsunami to hit Hawaii. This conclusion is based on the fact that earthquake tremors travel 970 kilometres per minute, while a tsunami travels 800 to 970 kilometres per hour in open waters. The exact speed depends on the depth of the water. Most tsunamis go undetected at sea. However, a tsunami may form a wall of water more than 30 metres high when it approaches shallow water near shore.

Tidal waves caused by large storms at sea are called *storm surges.* The size of a storm surge depends on the wind velocity, the duration of the storm, the sea distance over which the wind blows, and the barometric pressure. Storm surges are especially destructive if they hit the shoreline during high tide.

In 1900, Galveston, Texas, U.S.A., suffered great damage from a hurricane accompanied by a storm surge. In 1946, a tsunami severely damaged Hilo, Hawaii. In 1970, a cyclone and storm surge struck East Pakistan (now Bangladesh), killing about 266,000 people. Another cyclone and storm surge struck Bangladesh in May 1985, killing about 10,000 people.

See also **Krakatau; Seiche.**

Tide is the rise and fall of large expanses of water, on a definite time schedule. Tides regulate the day for many people who live along the seacoasts of the world. The tide is important to the boy or girl who swims along the shore when the tide is "in" and digs clams on the uncovered tidal flats when the tide is "out." The tide signals the start and end of the working day to people who fish and need high water to leave or enter the harbour.

All bodies of water, large or small, are subject to the tide-producing forces of sun and moon. But it is only where the sea meets the land that tides are great enough to be readily noticed. In inland bodies of water, the regular rise and fall of the tide is so small that it is often masked by changes in level due to wind and weather. Lake Superior, between the United States and Canada, for example, has a tide that rises and falls only about 5 centimetres.

Great harbours and seaports make use of the tides in many ways. The tidal currents help to sweep out the main channels and keep them deep. Ocean liners and cargo steamers use high tide to pass through shallow harbour entrances, for at that time there is sufficiently deep water to float them. Tides help to keep harbours clean and healthy. They pick up waste material from the coastline and carry it to deep water where it settles to the bottom.

Tides also occur on land and in the atmosphere, but they are much harder to observe than sea tides. Land and atmospheric tides can be detected only by highly-sensitive scientific instruments.

Tides follow the moon in its apparent motion around the earth. The tides rise and fall twice in the time between two rising moons, about 24 hours and 50 minutes. The time between two rising moons is determined by two motions: (1) the rotation of the earth on its axis, and (2) the revolution of the moon around the earth. As the earth turns on its axis, the moon appears to sweep across the sky once a day. But relative to the sun, the moon revolves around the earth once in about $29\frac{1}{2}$ days. Therefore, the moon moves about 12° around the earth each day. Between successive risings of the moon, the earth makes a complete rotation and then turns this additional 12°. The extra 12° of turning takes about 50 minutes.

People have known for thousands of years that the moon has some relationship to the tides. Before the year A.D. 100, the Roman naturalist Pliny wrote of the moon's influence on the tides. But the physical laws of tides were not worked out until after the English scientist Sir Isaac Newton discovered the law of gravitation in the 1600's.

The moon's gravity pulls the water nearest the moon slightly away from the solid part of the earth. At the same time, the moon pulls the solid earth slightly away from the water on the opposite side of the earth. In this way, the moon's gravity produces two bulges on the sea. These bulges are the positions of high tide.

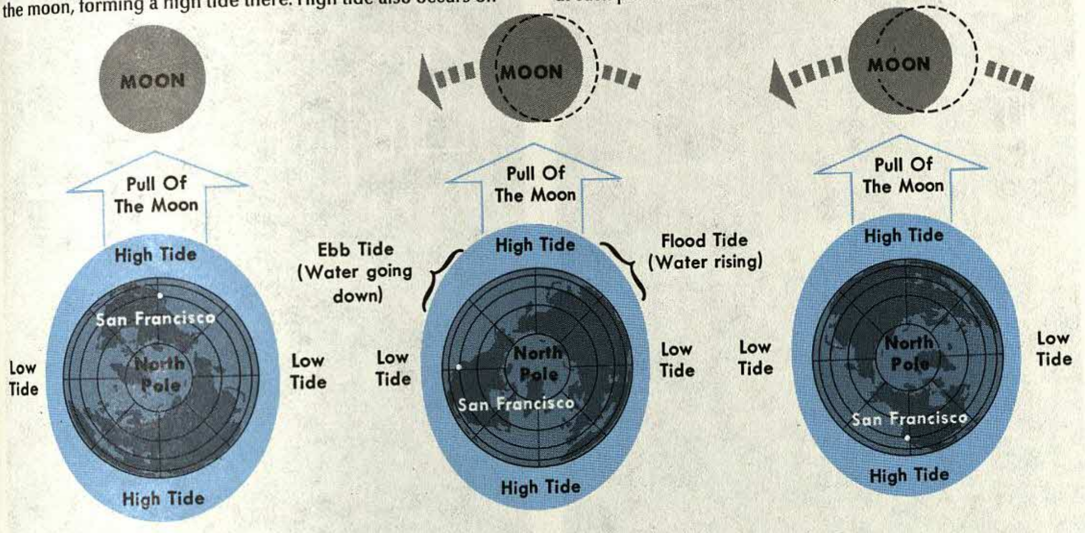
As the earth turns on its axis, the land and water rotate together. But one tidal bulge always stays under the moon, and the other tidal bulge always stays on the opposite side of the earth. Therefore, the earth's rotation brings a high tide to most places on the sea about twice a day. The two high tides at a given place do not usually rise equally high, because the centres of the tidal bulges usually lie on opposite sides of the equator. The centres are located there instead of on the equator because the moon is usually located either north or south of the plane of the equator.

Both the sun and the moon exert a pull on the earth called *gravitation.* The force of this pull depends on the body's *mass* (amount of matter) and on the distance of the body from the earth. The force is proportional to the mass of the body. Therefore, if the body's mass could be doubled, the body would exert twice as much force on the earth. The force is inversely proportional to the *square of the distance* (the distance multiplied by itself) between the body and the earth. If the distance of the body from the earth could be doubled, the body would exert only one-quarter as much force on the earth.

The sun and the moon pull harder on the side of the earth nearest them than they do on the centre of the earth, because the centre of the earth is farther away. It is this difference in pull that produces the tides. The dif-

Causes of sea tides

Tides in the sea are caused mainly by the pull of the moon on the earth. The moon's gravity pulls up the water directly below the moon, forming a high tide there. High tide also occurs on the other side of the earth, because the moon pulls the solid earth away from the water. As the earth turns, high tide occurs at each place on the sea twice a day.



High tide occurs directly below the moon and on the opposite side of the earth. When the earth is in the position above, San Francisco has a high tide.

As the earth turns, the tides rise and fall at each place on the sea. About 6 hours and 13 minutes after high tide, San Francisco has a low tide, *above.*

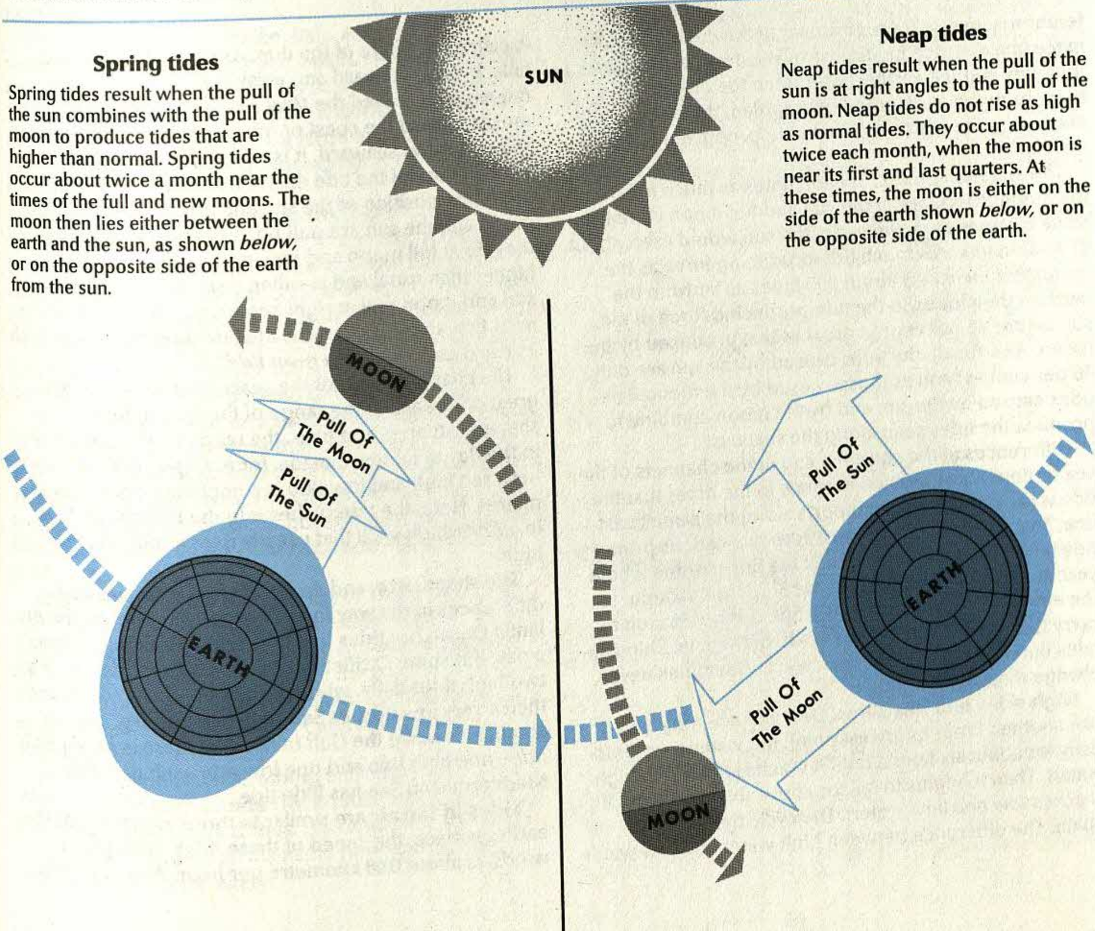
The next high tide at San Francisco occurs about 12 hours and 25 minutes after the first. The earth has turned 186° in this time. The moon has moved 6°.

Spring tides

Spring tides result when the pull of the sun combines with the pull of the moon to produce tides that are higher than normal. Spring tides occur about twice a month near the times of the full and new moons. The moon then lies either between the earth and the sun, as shown *below,* or on the opposite side of the earth from the sun.

Neap tides

Neap tides result when the pull of the sun is at right angles to the pull of the moon. Neap tides do not rise as high as normal tides. They occur about twice each month, when the moon is near its first and last quarters. At these times, the moon is either on the side of the earth shown *below,* or on the opposite side of the earth.



Tides rise and fall in a cycle that is regulated by the moon's gravity. When the water is at *low tide, left,* it rises gradually for about 6 hours, until it reaches *high tide, right.* Then it falls gradually for about 6 hours until it is at low tide again.

ference is inversely proportional to the *cube of the distance* (the distance multiplied by itself twice) between the body and the earth. Therefore, if the distance of a body from the earth could be doubled, the body would exert only one-eighth as much tide-producing force on the earth.

The sun has about 27 million times as much mass as the moon. Therefore, if the sun and the moon were the same distance from the earth, the sun would exert about 27 million times as much tide-producing force as the moon. But the sun is about 390 times as far from the earth as the moon. So the tide-producing force of the sun is only 46 per cent as great as that produced by the moon. As a result, the tides caused by the sun are only 46 per cent as high as those caused by the moon. The tides caused by the sun and by the moon combine to produce the tides seen along the seacoast.

Differences in the coastline and in the channels of the sea bottom may make a difference in the times that the tide wave hits the different ports along the same coastline. The governments of most seacoast nations print tide tables showing the times of the tides for the whole year at main ports of the country. Ships are brought to the entrance of a port when the tide is high enough to carry them and is on the flood to help them in. Ship captains find tide tables dependable—for tide times never change their regular pattern.

High tides and low tides. One tide acts very much like another. From its lowest point, the water rises gradually for about six hours, until it reaches *high tide* (high water). Then it begins to fall for about six hours, until it reaches *low tide* (low water). The cycle then begins again. The difference between high water and low water is called the *range* of the tide. As the water rises and falls, it moves toward and away from the coast. This movement is called the *tidal current.* When the water moves toward the coast or inland, it is the *flood current.* When it flows seaward, it is called the *ebb current.*

The range of the tide differs from day to day according to the position of the sun and the moon. When the moon and the sun are pulling along the same line, as they do at full moon and new moon, the tide rises higher than usual and is called a *spring tide.* When the sun and moon pull at right angles, as when the moon is in its first and last quarters, the tide does not rise as high as usual and is called a *neap tide.*

The characteristics of the seacoast itself also make a great difference in the range of the tide. In funnel-shaped estuaries and bays, the range may be very high. In the Bay of Fundy, Canada, for example, the difference between high and low tide is sometimes more than 15 metres. Here, the tide rushes into the Petitcodiac River in a *bore* (high wall) that usually rises about 0.5 metre high.

The shape, size, and depth of seas or oceans make differences in the way the tide acts. For example, the Atlantic Ocean has tides that flow and ebb regularly twice a day. But some Pacific islands have *mixed tides,* such as two high tides daily, with only a little ebb between, and then a very low tide. At Saint Michael, Alaska, and certain places along the Gulf of Mexico, there is only a *daily tide*—one high tide and one low tide each day. The Mediterranean Sea has little tide.

Tides in the air are similar to those in the sea. At the earth's surface, the speed of these tides, called *lunar winds,* is about 0.08 kilometre per hour. Although they are too low to be felt, scientists detect them by studying variations in weather statistics. High and low tides in the air come twice daily. There also are high stages that are equivalent to the sea's spring tide. Lunar winds blow eastward in the morning and westward in the evening.

See also **Bay of Fundy; Bore; Energy supply** (Tidal energy); **Ocean** (The tides); **Sea level; Seashore; Tidal wave.**

Tie dyeing is a method of dyeing cloth to produce a design. Tie dyeing is one of the oldest methods of printing designs on fabric, and various techniques are found in many cultures. Typically, parts of a woven material are bunched together in a design and knotted or tied with a cord or string. The fabric is then submerged in dye. The tied sections are protected from absorbing the dye, thus creating the design. The fabric can be retied and submerged into dyes of other colours to create new patterns and colour combinations.

Tien Shan. See Tian Shan.

Tientsin. See Tianjin.

Tiepolo, Giovanni Battista (1696-1770), was the last important Italian painter of the Venetian group. He began as an admirer of Paolo Veronese, but he soon developed a grand, colourful mural style that became popular in Europe during the 1700's. Many of his murals portray historical scenes and fantastic allegories. They show active figures painted in lively pastel colours. His painting *Allegory of the Marriage of Frederick Barbarossa and Beatrice of Burgundy* is reproduced in the **Painting** article.

Tiepolo was born in Venice, Italy. After 1750, he worked mainly in Germany and Spain. His works include decorations for the archbishop's palace in Würzburg, Germany, and the Royal Palace in Madrid. Some of Tiepolo's small oil sketches for his large murals are displayed in the Metropolitan Museum of Art in New York City.

See also **Painting** (Painting as decoration).

Tierra del Fuego is the name of a group of islands lying off the extreme southern tip of South America. The name *Tierra del Fuego* means *Land of Fire.* In 1520, Ferdinand Magellan named the region when he sighted large fires blazing along the shore. He was trying to find a passage to the Pacific. The Indians who lived there usually kept many fires burning to warm themselves.

The islands cover about 69,600 square kilometres. The Strait of Magellan separates them from the mainland. The largest island, also called Tierra del Fuego, covers 49,935 square kilometres. The city of Ushuaia, the world's southernmost seat of government, lies on this island. The islanders are called *Fuegians.* The population is about 36,000.

Argentina owns the eastern part of Tierra del Fuego island, while Chile controls the western part. In 1948, an Italian settlement was made in the Argentine section. Each country also owns several of the smaller islands. Chile controls the Strait of Magellan, and maintains a naval base on Navarino Island. Cape Horn is at the southern tip of the islands.

See also **Cape Horn; Clothing** (introduction).

Tiffany, Charles Lewis (1812-1902), was an American dealer in precious stones. His reputation as a jeweller became so great that his name now stands for the highest quality in jewellery.

Tiffany was born in Killingly, Connecticut, U.S.A. He went to New York City in 1837 and opened a small haberdashery shop. He soon was specializing in jewellery, glassware, and china. Later he imported European crown jewels. He also set up factories to make some products he sold. Louis Comfort Tiffany, his son, created the famous Tiffany glass (see **Tiffany, Louis Comfort**).

Tiffany, Louis Comfort (1848-1933), was a major stained-glass designer of the late 1800's and early 1900's. He was an important American figure in the establishment of an international art style called *art nouveau.* The style flourished from about the 1890's to about 1910 (see **Art nouveau**).

Tiffany was born in New York City. Charles Lewis Tiffany, his father, founded a famous jewellery business. Tiffany began his career as a painter, but soon developed an interest in the decorative arts, especially stained glass. In 1879, he formed a partnership with several modern artists. The firm specialized in contemporary interior design. In 1880, Tiffany took out a patent for coloured glass that was *iridescent*—that is, it changed colours when viewed from different angles. In 1885, he formed his own glass company. In 1894, Tiffany registered the name *Favrile* to describe his handmade works in iridescent glass.

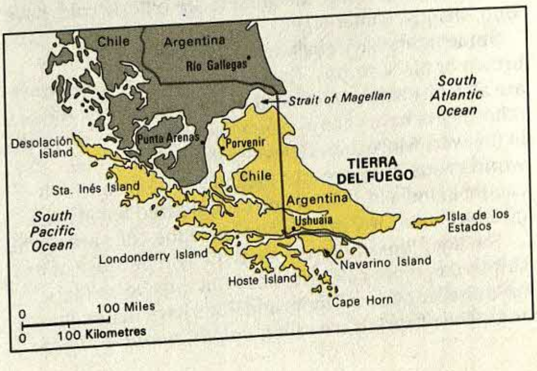
See also **Glass** (picture: Stained-glass windows).

Tiflis. See **Tbilisi.**

Tiger is the largest member of the cat family. People admire the tiger for its strength and beauty, but they fear it because it has been known to kill and eat people. Yet almost all wild tigers avoid people. Probably only 3 or 4 out of every 1,000 tigers ever eat people, and some of these tigers are sick or wounded animals that can no longer hunt large, fast-footed prey.

Wild tigers are found only in Asia. Until the 1800's, many lived throughout most of the southern half of the continent. Tigers still live in some of this area, but only a

Tierra del Fuego is a group of islands at the southern tip of South America. The islands are divided between Argentina and Chile.



The tiger's coloration helps conceal the animal in its natural surroundings. This female tiger could easily go unseen because her stripes blend with the tall grasses.

few are left. People have greatly reduced the number of tigers by hunting them and by clearing the forests in which they lived. Today, wildlife experts consider the tiger an endangered species.

The different *races* (types) of tigers live in a wide range of climates. They are found in the hot rainforests of Malaya, the dry thorn woods of India, and the cold, snowy spruce forests of northern China. They also live in oak woods, tall grasslands, swamps, and marshes. Tigers prefer to be in the shadows and seldom go into open country as lions do.

The body of a tiger. Adult male tigers weigh about 190 kilograms and are about 2.7 metres long, including a tail of almost 0.9 metre. Adult *tigresses* (females) weigh about 140 kilograms and are slightly smaller. The tiger's coat ranges from brownish-yellow to orange-red and is marked by black stripes. The stripes differ greatly in length, width, and spacing. The fur on the throat, belly, and insides of the legs is whitish. Many tigers, especially males, have a ruff of hair around the sides of the head, but the hair is not so long as the mane of lions. The tigers of Siberia, where the winters are bitterly cold, have long, shaggy, winter coats.

Some tigers have chalk-white fur with chocolate-brown or black stripes. These tigers, called *white tigers,* are also distinctive because they have blue eyes. All other tigers have yellow eyes. White tigers are very rare in the wild. More than 100 white tigers live in the world's zoos. They are all descendants of a white cub caught in India in 1951. A normal-coloured female can give birth to a litter in which some of the cubs are white.

The tiger looks different from the lion because of its stripes and more colourful coat. But the two animals have similar bodies. Tigers and lions have mated in zoos. The offspring are called *tiglons, tigons,* or *ligers.*

How a tiger hunts. Tigers prefer large prey, such as deer, antelope, wild oxen, and wild pigs. Some tigers attack elephant calves. They also eat small prey, such as peafowl, monkeys, tortoises, and frogs. Tigers especially like porcupines, but their quills may cause painful wounds. In parts of Asia, some tigers prey on domestic cattle and buffalo because of the scarcity of wildlife.

The tiger usually hunts at night, wandering over animal trails and along stream beds. A tiger depends on its sharp eyes and keen ears, but it may also use its sense of smell. The tiger, waiting in cover, rushes at its prey in a series of bounds. Using its sharp claws, the tiger grasps its victim by the rump or side and pulls it to the ground. The tiger's teeth are well suited both for holding prey and for tearing off chunks of meat.

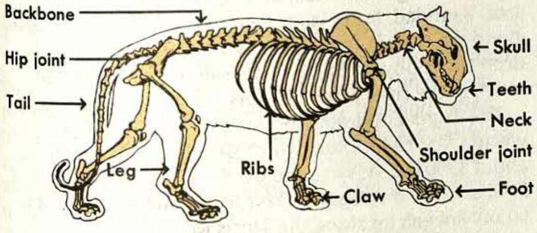
Tigers are extremely swift for short distances and can leap nearly 9 metres. But if a tiger fails to catch its prey quickly, it usually will give up because it soon tires. As long as a week may go by without a successful hunt. After a kill, the tiger drags the *carcass* (dead body) to thick cover, preferably near water. The muscles of the tiger's neck, shoulders, and forelegs are very powerful.

Facts in brief about tigers

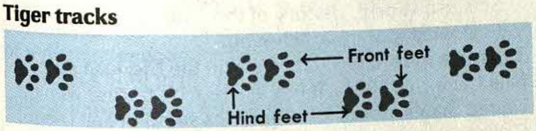
Names: *Male,* tiger; *female,* tigress; *young,* cub.
Gestation period: 98 to 109 days.
Number of newborn: 1 to 6, usually 2 or 3.
Length of life: Up to 20 years.
Where found: Chiefly in Bangladesh, India, Nepal, and Southeast Asia, including Sumatra; also a few in China, Iran, and Korea, and along the Siberian-Manchurian border.
Scientific classification: Tigers belong to the class Mammalia and the order Carnivora. They are in the cat family, Felidae, and the genus *Panthera.* All tigers are of the same species, *P. tigris.*

The male tiger has heavier patches of fur around its face than the female. This male is taking a dip on a hot day.

The skeleton of a tiger

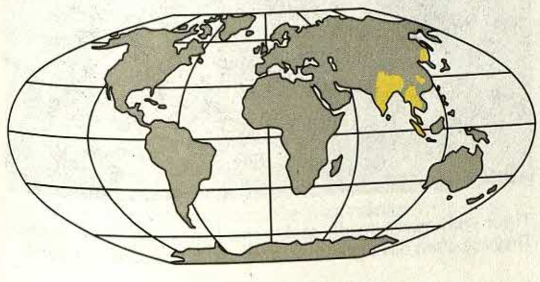


Tiger tracks



Where tigers live

The yellow areas in the map below show the parts of the world where tigers are found. Most tigers live in southern Asia.



A tiger may drag the body of a 230-kilogram young water buffalo 0.5 kilometre. The tiger stays near the carcass until it has eaten everything except the bones and stomach. A tiger may eat 23 kilograms of meat in a night. A long drink and a nap often follow a meal.

Tigers are good swimmers and may swim across rivers or from one island to another in search of prey. Tigers can climb trees, but they do not usually do so.

The life of a tiger. Adult tigers usually live alone, but they are not unfriendly. Two tigers may meet on their nightly rounds, rub heads together in greeting, and then part. Several tigers may share a kill.

Many adult males claim a territory as their own and keep other males out. The territory may average about 52 square kilometres, depending on the amount of prey available. The tiger marks a path with urine and with fluids from glands at the base of the tail. The scent lets other tigers know that the territory is occupied. A male's large territory includes the smaller territories of two or more females, each wandering alone but aware of one another. Tigers communicate by many sounds, including a very loud roar. Some tigers do not have territories and travel widely.

A tigress can bear her first cubs when she is $3\frac{1}{2}$ to 4 years old. She carries the young within her body for about $3\frac{1}{2}$ months. A tigress can give birth to from one to six cubs, though usually two or three. The cubs are helpless and weigh about 0.9 to 1.4 kilograms at birth. About half of the tiger cubs born die before they are a year old. The cubs cannot kill enough for themselves until they are more than a year old. Cubs become independent when about 2 years old. Tigers can live up to 20 years in the wild.

The rare tiger. There are eight subspecies of tiger. These subspecies are the Bali tiger, Bengal tiger, Caspian tiger, Indochinese tiger, Javan tiger, Siberian tiger, South China tiger, and Sumatran tiger. Of these, the Bali tiger, Caspian tiger, and Javan tiger are now extinct.

The other five subspecies are all gravely endangered, threatened by hunting and loss of forest habitat. There are fewer than 200 Siberian tigers in the wild, mainly in Russia. The South China tiger is even rarer, with an estimated 50 in the wild and another 50 held in zoos in China. There are probably about 1,500 Indochinese tigers, mainly in Malaysia and Thailand. The Sumatran tiger numbers about 650. The Bengal tiger makes up 60 per cent of the world's tiger population and is found mainly in India. Its numbers had declined from 4,400 in the mid 1980's to fewer than 3,750 in 1994. Demand for tiger carcasses for use in traditional Chinese remedies led to an increase in poaching after the 1980's, threatening the tiger with extinction.

See also **Animal** (Animals of the tropical forests; picture), **Lion; Sabre-toothed tiger.**

Tiger, Tasmanian. See **Tasmanian tiger.**

Tiger cat, or spotted-tailed quoll, is a flesh-eating marsupial that lives in eastern Australia and Tasmania. As one of six species of marsupial cats, it is more closely related to kangaroos than to cats. Early settlers in Australia thought the tiger cat resembled the pets they had known in Europe. Tiger cats are about 60 centimetres long and have 50-centimetre long tails. They have dark fur with white spots. They live on birds and other small creatures, some as large as small wallabies. Tiger cats

Tiger cats resemble the cats that are familiar as pets. But the tiger cat is more closely related to kangaroos than to cats.

are good climbers and spend much of their time in trees.

Scientific classification. Marsupial cats are in the family Dasyuridae. The tiger cat is *Dasyurus maculatus.*

Tiger lily is a tall garden flower that originally grew in eastern Asia. It received its name because it has reddish-orange flowers splashed with black. People in China, Japan, and Korea serve tiger lily bulbs as food.

The stem of the tiger lily is greenish-purple or dark brown, and many grow from about 0.5 to 1.5 metres tall. Tiny black bulblets appear where the long, spear-shaped leaves join the stalk. The bulblets finally drop off, producing new plants.

Tiger lilies grow best in bright sunlight, in a loose, fertile soil. They can withstand cold weather but need some protection in winter. The bulbs should be planted about 15 centimetres in the ground, with a little sand or gravel under each. After being planted, tiger lilies bloom from year to year with little care.

Scientific classification. The tiger lily belongs to the lily family, Liliaceae. It is *Lilium tigrinum.*

Tiger moth. See **Moth** (pictures).

Tiger shark gets its name from the characteristic prominent dark bars on its back and sides. The overall colour is bluish-grey. Tiger sharks grow to about 5 metres long. They have strongly *serrated* (sawlike) teeth. They are among the most dangerous of sharks.

Tiger sharks are *viviparous*—that is, they retain their eggs until the young hatch. They produce up to 46 young. They are common in the waters off Australia. Tiger sharks are also found elsewhere, even in the North Atlantic during the warmer months.

Scientific classification. The tiger shark belongs to the family Carchariidae. It is *Galeocerdo cuvier.*

Tiger snake is the name of one of Australia's deadliest snakes. It lives in southern Australia. The snakes range in colour from grey through various shades of brown and olive-green to black.

Tiger snakes can grow about 2 metres long, but most are less than 1.5 metres in length. The snakes eat frogs and a variety of small mammals.

Scientific classification. The tiger snake is in the family Elapidae. It is *Notechis scutatus.*

Tiglath-pileser III (?-727 B.C.) was a king of Assyria, a land centred in what is now northern Iraq. He ruled from 744 to 727 B.C.

Tiglath-pileser began the greatest expansion of the Assyrian empire. He defeated the rival kingdom of Urartu, which lay north of Assyria, mainly in what is now Armenia and Turkey. He also extended Assyrian control across the Euphrates River into Syria and Palestine. He conquered the ancient kingdom of Israel and made part of it a province directly under Assyrian control. The remainder of Israel and the kingdom of Judah became *vassal states* of Assyria. Under this arrangement, the kings of Israel and Judah recognized the king of Assyria as their superior and made payments to him. Tiglath-pileser also seized Babylon and, in 729 B.C., was crowned king of Babylonia.

Tiglath-pileser reorganized the Assyrian imperial system. He removed members of the Assyrian nobility from provincial governorships and replaced them with generals and officials from the royal court. These officials were responsible directly to the king.

Tiglon. See **Lion** (Cubs).

Tigris River is a major river of southwestern Asia. It is about 1,900 kilometres long and forms part of the historic Tigris-Euphrates river system. The Tigris rises in mountainous terrain in eastern Turkey, flows southeast to the border between Turkey and Syria, and then enters Iraq. The river winds through Iraq and gradually descends to low, flat land. At the town of Al Qurnah, Iraq, it joins with the Euphrates River to form the Shatt al Arab. The Shatt al Arab flows into the Persian Gulf. For the location of the Tigris, see **Iraq** (map); **Euphrates River** (map).

The area near and between the Tigris and Euphrates rivers has Iraq's most fertile soil, and the rivers provide water for irrigation. Most of Iraq's people live in this area. Baghdad, Iraq's largest city, lies on the Tigris. Dams along the river in Iraq store water used to generate hydroelectric power. Small boats sail on the Tigris, but much of the river is too shallow for large vessels.

The Tigris-Euphrates region was the site of the world's first civilization, which developed in Sumer about 3500 B.C. Assyria and other early civilizations also flourished in the region. The ruins of the Assyrian capital of Nineveh lie along the Tigris River.

See also **World, History of the** (The Tigris-Euphrates Valley); **Mesopotamia; Nineveh.**

Tijuana (pop. 698,752) is a city in the Mexican state of Baja California Norte. It lies at Mexico's border with the United States, about 25 kilometres south of San Diego, California (see **Mexico** [political map]).

Tiger snakes are deadly snakes that live in southern Australia. They are often olive-green or brown with irregular dark bands.

Tijuana is a modern city with attractive public buildings and luxury hotels. Tourists from the United States spend millions of dollars in Tijuana each year. The city's attractions include gift shops, fine restaurants, nightclubs, bullfights, and horse races. Tijuana is in a *free trade zone,* where shoppers may buy items imported from outside Mexico without paying a Mexican import tax. Tijuana produces electronic products and clothing. It is an export centre for grapes, tomatoes, and onions.

Tijuana's name may be derived from an Indian name for the region, or from a huge ranch in the area called the *Tia Juana* (Aunt Jane). During the early 1900's, Tijuana was a small village of about 200 people. Since 1940, the city has grown rapidly because of its booming tourist trade.

Tikhonov, Nikolai Aleksandrovich (1905-), served as premier of the Soviet Union from 1980 to 1985. The premier—officially chairman of the Council of Ministers—was the chief administrator of the Soviet government. At that time, however, the general secretary of the Soviet Communist Party was actually the most powerful person in the government.

Tikhonov was born in Kharkov, Russia. He earned an engineering degree in Dnepropetrovsk and worked as an engineer and plant manager in factories. Tikhonov joined the Communist Party in 1940. Beginning in 1950, he held various industrial management positions in government. From 1957 to 1960, he headed the Dnepropetrovsk economic council. During the 1960's and 1970's, Tikhonov rose through the ranks of the Soviet government's Council of Ministers. He became a full member of the policymaking Politburo of the Communist Party in 1979. He resigned as premier and from the Politburo in 1985 for reasons of health.

Tiki is a Maori neck pendant in the form of a human figure (see **Maoris**). The hands have three fingers and the legs are usually bent under the body. The Maoris preferred to use *greenstone* (jade) for tikis and called these pendants *heitiki.* Most of the figures are female, in spite of a connection between the pendant and the mythological figure, also called Tiki, who was believed to be the first man.

Tilak, Bal Gangadhar (1856-1920), an Indian politician and journalist, was an early leader in the campaign for Indian independence from British rule.

Tilak was born in the Ratnagiri district on the west coast of India. He was educated at Deccan College in Pune, where he obtained degrees in arts and law. He worked as a teacher at the New English School, and also wrote regularly in the newspapers *Kesari (The Lion),* published in the Marathi language, and *The Mahratta,* published in English. He was fined for his criticism of the government.

During a famine in 1896 and a plague epidemic in 1897, Tilak tried to help the people suffering in these two disasters. He criticized government methods used to combat the plague and was imprisoned for 18 months. In 1905, he criticized the government strongly over its decision to divide Bengal. The following year, Tilak set out a plan of action to achieve *swaraj* (self rule). It involved buying only Indian-made goods and refusing to buy British-manufactured articles. In 1908, the British imprisoned him for six years. He was released in 1914. Tilak formed the Indian Home Rule League in 1916.

Tilbury. See **Thurrock.**

Tile. All the several kinds of clay tile are made in much the same way. Thin sheets of clay are pressed, moulded, and baked in kilns in the same process as is used for making brick. The tile may be left in its rough state. It may also be given a smooth surface, called *glazing,* by throwing salt into the kiln or by treating the clay with a chemical wash.

Tile pipe is used for sewage-disposal systems and for draining fields of excess water. A continuous tile line is formed by fitting together short sections, each of which has one end enlarged to form a bell into which the small end of the next section fits. Drain tiles are generally laid with uncemented butt ends through which the drainage water may seep. Sewer pipes are laid with tight cement joints.

Finer grades of clay are used in making tiles for roofs, for walls, and for floors. Roofing tiles are made in various shapes and colours. Hollow clay tile blocks are used in load-bearing walls and partitions.

Home builders use decorative tiles for interior floors and walls. They obtain artistic effects by using tiles of different colours. Mosaics are small, unglazed tiles that are combined to form a design. White and coloured glazed tiles are popular for kitchen and bathroom walls. *Encaustic tiling* is the trade name for decorative tiles used in such a way that there is a background of one colour and a pattern of another, contrasting colour.

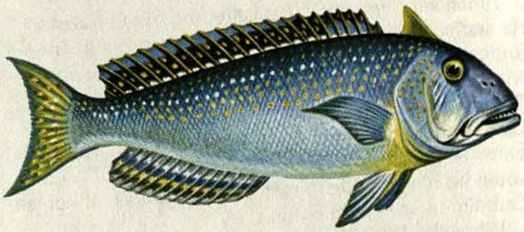
Floor tiles are made of rubber, linoleum, terrazzo, cork, asphalt, plastic, and terracotta and other ceramics. Acoustic ceiling tiles are made of cork granules, wood fibre, and mineral fibre.

See also **Clay; Terracotta.**

Tilefish is a deep-sea fish that lives along the northeast coast of North America. It lives in a restricted depth of about 80 to 180 metres.

The tilefish is the most colourfully decorated fish in northern waters. The body is bluish or olive-green above, fading to pale blue below. The upper sides are thickly dotted with small yellow spots. Tilefish can grow to about 90 centimetres long and may weigh as much as 20 kilograms. They feed chiefly on squid, crabs, and other shellfish. They are an excellent food fish, and can be caught on trawl lines and hand lines with any kind of bait.

Scientific classification. The tilefish belongs to the tilefish family, Branchiostegidae. It is *Lopholatilus chamaeleonticeps.*



The tilefish lives along the northeastern coast of North America.

Till Eulenspiegel. See **Eulenspiegel, Till.**

Tillage. See **Agriculture** (Kinds of agriculture: Methods of crop production).

Vesta Tilley

Tilley, Vesta (1864-1952), was a male impersonator who appeared mainly in British music halls. Usually wearing evening dress and top hat, she sang the songs that made her famous. They included "Burlington Bertie," "The Army of Today's All Right," and "Following in Father's Footsteps."

Vesta Tilley was born in Worcester, England, and named Matilda Alice Powles. At the height of her popularity, she was known as the "London Idol." She married Sir Walter de Frece, and retired from the stage in 1920, after a final appearance at the Coliseum Theatre, London.

Tillich, Paul (1886-1965), was an important German-born theologian. Tillich was a brilliant student of culture. In *Theology of Culture* (1959), he analysed the forms of culture, showing the religious dimension in all cultural activities. Tillich developed a theory of religious symbols and myths, which he discussed in *Dynamics of Faith* (1957). His masterpiece is the three-volume *Systematic Theology* (1951, 1959, 1963). In this work, Tillich interpreted the meaning of God and Jesus Christ in correlation with philosophical questions of modern life and thought.

Paul Johannes Tillich was born in Starsiedel, near Leipzig, Germany. His thought and life were transformed by his experiences as a Lutheran chaplain in World War I (1914-1918). He encountered what he called "the power of nonbeing" in the wartime anxieties of the soldiers concerning death, guilt, and loss of meaning. In *The Courage to Be* (1952), he understood God to mean "the power of being itself" in the experience of courageously conquering anxiety.

Tillich left Germany in 1933 after the rise of Nazism. He settled in the United States, teaching at Union Theological Seminary, New York City, Harvard University, Massachusetts, and the University of Chicago.

Tilly, Count of (1559-1632), was a leading Roman Catholic general during the Thirty Years' War, a struggle between European Catholics and Protestants. Tilly devoted his life to trying to restore the influence of Roman Catholicism in central Europe.

When the Thirty Years' War broke out in 1618, Tilly took command of the Catholic Holy League. He won important early victories over both the Bohemians and Danes. But he was defeated at the Battle of Breitenfeld by King Gustavus Adolphus of Sweden in 1631. Tilly then raised a new army to oppose the advancing Protestants. He was wounded during a battle with Swedish forces along the Lech River in Germany, and died soon afterward in Ingolstadt, Germany.

Tilly was born Johan Tserclaes, in Gembloux, Belgium. In 1843, a statue of Tilly was placed in the Hall of Generals in Munich, Germany.

See also **Thirty Years' War.**

Timber includes logs and unprocessed wood, as well as standing trees. It is also the term applied to boards and larger pieces of wood that have been sawed from logs. In Canada, the United States, and some other countries, timber is referred to as *lumber*. Almost every house uses some timber in its construction. Timber furnishes material for flooring, woodwork, doors, and other building parts. In industrial countries, a large proportion of the timber cut is used by the construction industry. The remainder goes from the sawmills to factories that manufacture boxes, crates, furniture, farm tools, toys, railway carriages, boats, and hundreds of other products.

Every time a piece of wood is cut at a sawmill, sawdust and small pieces of wood fall to the floor. These leftover bits of wood can be made into many valuable products. Often, mills send both logs and wood scraps through a chipper. Pulp mills treat the chips with chemicals that change them into wood pulp. Manufacturers use pulp to make paper, plastics, rayon, and other products. Sawdust is used for fuel, insulation, and packing material. For a description of the products obtained from trees, see **Forest products.**

The timber industry employs thousands of people to *fell* (cut down) trees, transport logs to mills, saw logs into boards, and to sell the boards. The United States uses almost 246 million cubic metres of timber every year, more than any other country. The United States leads the world in timber production. Other important timber producers include Brazil, Canada, China, India, Japan, Russia, and Sweden.

Kinds of timber

Timber experts divide timber into two main classes: *softwood* and *hardwood*. These classes are not based on the softness or hardness of the wood. They refer to the kind of tree from which the timber came. Some softwood timber is harder to cut or saw through than most hardwood. Also, timber from certain hardwood trees is softer than timber from most softwoods.

Timber is also classified by its condition. *Rough timber* has straight sides and edges, but is rough and splintery. *Dressed timber* comes in smooth, evenly cut boards. *Worked timber* is dressed timber that has a design cut in it for decoration or to make boards fit together.

Softwood timber comes from trees called *conifers*. The word refers to the cones in which the seeds of most softwood trees develop (see **Conifer**). Common conifers include pines and firs. These trees have thin, waxy, needle-shaped or scale-like leaves. They are also called *needleleaf trees* or *evergreens*. Other softwood trees include spruce, larch, hemlock and redwood. Their wood is used for doors, frames, panels, other building materials, and boxes.

Softwood timber is sometimes classified according to its use. *Structural timber*, for example, can stand heavy strain. It is used for posts, planks, joists, and beams.

Hardwood timber is sawed from broad-leaved trees. These trees are usually *deciduous,* which means they lose their leaves in autumn (see **Deciduous tree**). Hardwoods used for timber include oak, maple, chestnut, birch, walnut, elm, ash, aspen, and beech. Tropical hardwoods, such as mahogany, ebony, teak, and rosewood, are used in high-quality furniture. Hardwoods are also used for panelling, flooring, tool handles, and many other items.

Much hardwood timber is sawed into small pieces called *hardwood dimension parts.* This cuts out defects and provides greater usefulness. Manufacturers use it to make chair arms, piano legs, and other furniture parts. When furniture or tool factories want plain blocks of hardwood, they order *rough hardwood dimension.* If they need trimmed, moulded, or sanded wood, they order *surfaced hardwood dimension.* If manufacturers want parts of a chair, such as legs, arms, or seats, ready to be assembled, they order *finished market products.*

From forest to sawmill

Forest products industries throughout the world own vast areas of forest. They employ *logging* companies to harvest the trees—to cut them down and transport them from the forest to the sawmill.

Cutting down trees. Before the logging companies go into the woods, a forestry worker decides which trees they should fell. The forestry worker is a scientist trained in growing crops of trees so that they will yield the greatest possible amount of timber. He or she also knows how to protect forests from fire, insects, disease, and grazing animals. See **Forestry.**

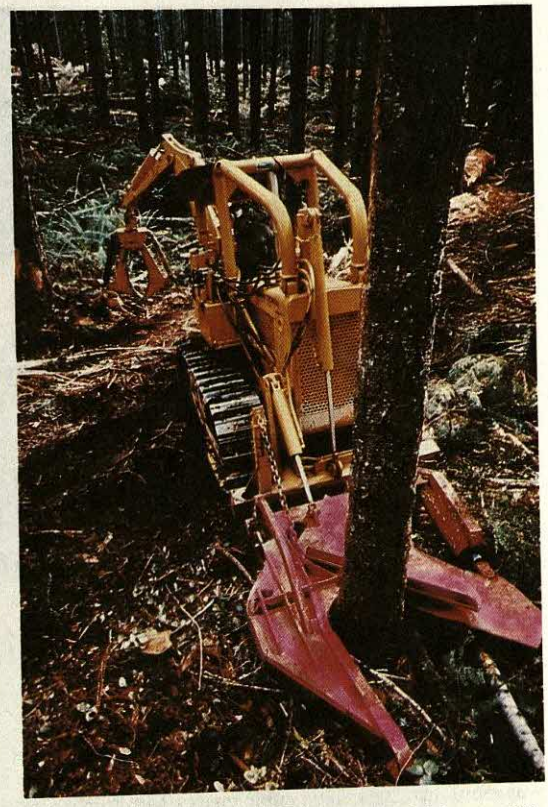
Forestry workers called *tree fellers* will fell trees that the forester has marked for felling. The power saw that the fellers use may weigh as much as 18 kilograms. With its small petrol motor and whirling chain saw, it can slice through a tree trunk in a few seconds.

In felling a tree, the feller first makes an *undercut.* A wedge-shaped piece is cut out of the tree trunk with an axe or power saw. The feller makes the undercut on the side of the tree that is to fall to the ground. The cut is made close to the ground to avoid wasting valuable wood by leaving a high stump. After the saw has cut through the tree trunk, the undercut makes the tree lose its balance and fall to that side. Expert fellers can drop a tree exactly where they want it. They can avoid striking other trees, or hitting stumps that might break or damage the trunk of the falling tree.

Some tree trunks may measure 60 metres or more in length. Workers called *loggers* or *lumberjacks* cut the trunks into shorter lengths, so that they can take them out of the forest more easily. They use axes or power saws to lop off the limbs. Then they saw the trunks into logs from about 2.5 to 12 metres long.

Since the mid-1900's, large modern machines have simplified the work of loggers. For example, hydraulic *tree shears* quickly cut through a tree like giant scissors. They are built into tractors that move from tree to tree. Other machines do more than one job. Some *tree harvesters* fell a tree, remove its branches, cut it into logs, and sort the logs. The most advanced machines can also strip the bark from the tree before it leaves the forest.

Transporting logs from the forest to the sawmill is the second step in logging. It consists of two operations. First, forestry workers *skid* (drag or haul) the logs to the *landing* (a central place in the woods). Then they transport the logs from the landing to the sawmill.

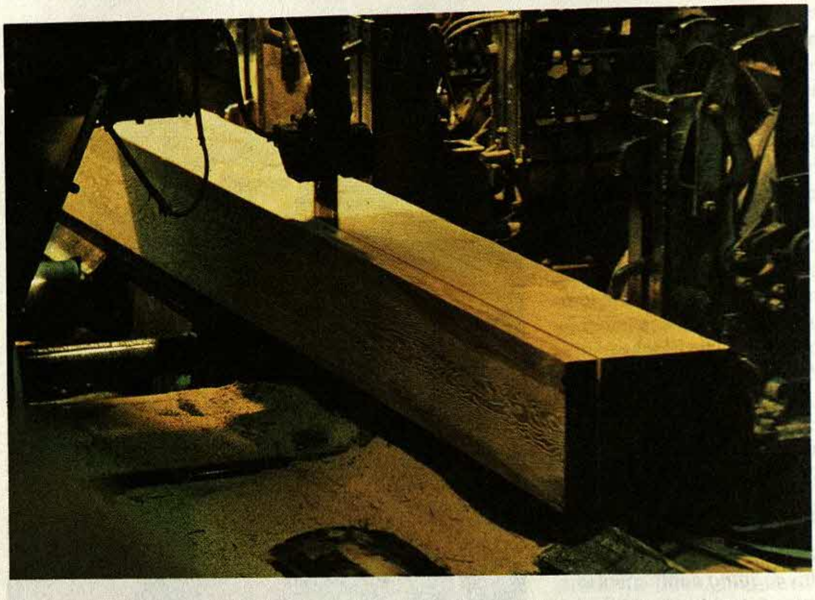


Hydraulic tree shears have jaws so powerful that they can fell a tree in a fraction of the time taken by a saw.

Forestry workers use horses, tractors, or long cables called *draglines* to skid the logs to the landing. Usually, the logs are hauled over the ground. But sometimes forestry workers transport them in special carriers. In some countries, forestry workers use big sledges to carry logs over icy roads in winter. If there is a stream or river nearby, a chute may be built to slide logs down into the water, so that they may be easily transported downstream.

A system called *high-lead logging* uses pulleys and steel cables to drag logs up steep slopes or to swing them across ravines. The pulleys and cables are supported by portable towers and are powered by giant diesel, steam, or electric winches. The cables pick up only one end of the log. The other end may drag along the ground. High-lead logging can bring logs to a landing as far away as 500 metres. Other cable-logging systems can carry logs 750 metres or more. Such systems use cables called *skylines.* Skylines pick up the entire log instead of dragging one end along the ground. Logging with skylines does less damage to the forest floor than high-lead logging.

After skidding, the logs are piled at the landing until they can be moved to the mill. If the landing lies near a road, trucks carry the logs to the mill. If it is on a railway line, flatcars transport the logs. If the landing is on the



A large log is cut into timber at a sawmill. The log, mounted on a moving platform called a *carriage,* travels back and forth past a large *headsaw.* The headsaw slices a piece of timber each time the carriage goes by.

bank of a stream or river, workers use chains to bind the logs into rafts that float to the mill. Sometimes barges carry logs. Trucks transport the largest number of logs to sawmills.

From sawmill to timberyard

The total world production of sawed wood in 1988 was more than 500 million cubic metres. Most timber in the world comes from small sawmills, which may produce only a few thousand cubic metres a year. Some portable sawmills are so small that the *headrig,* or sawing machinery, can be loaded onto a truck trailer and be hauled into the forest.

Some softwood mills stand beside a pool of water, or a dammed section of a river. The logs are kept in the pool until they go into the mill. The water protects them from insects, fungi, stain, and fire. A growing number of softwood mills store their logs on dry land and handle them with modern loading devices. Hardwood mills also store their logs on dry land because heavy hardwood logs may sink in water.

Sawing logs. A moving conveyor belt carries the logs up a wooden chute into the mill. Jets of water forced through overhead pipes clean the logs. When the logs enter the mill, no sand, dirt, or bits of metal remain on them because any of these things might dull the sharp saw blade.

In many mills, a *log debarker* removes the bark before the log reaches the first saw, called a *headsaw.* One kind of debarker consists of metal bars or knives that rub off or chip off the bark. Another type of debarker tears off the bark by the force of water shot onto the log under great pressure.

As a log enters the sawmill, machinery moves it onto a platform called a *carriage.* The carriage looks somewhat like a small railway flatcar. It carries the logs into the teeth of the headsaw. The saw makes a screaming sound as it tears into the wood. Each time the carriage goes past the saw, the saw slices off a board, until the log has become a pile of boards.

Moving belts then carry the newly made boards called *green timber,* to the *edger,* a set of smaller saws. These saws trim the rough edges from each board and make the sides straight and even. Next, the edged boards go to the *trimmer.* This set of saws makes the ends of the boards square, and cuts the boards to the exact lengths ordered by timber dealers. The trimmer also cuts off weak or bad spots.

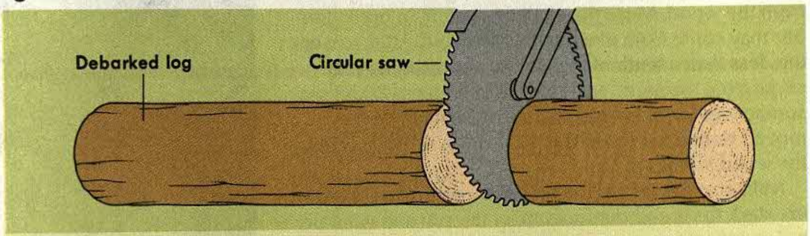
Gang saws are used at sawmills in some countries. In these mills, after the outer slabs of the logs are removed, the edged log moves into a set of several straight-bladed saws. These saws are spaced to cut the "squared-up" log into boards of the desired thickness in one operation.

Grading timber. The green boards, now called *rough timber,* ride slowly on a moving conveyor belt. Workers called *graders* walk it, examining each board carefully and deciding its grade. They sort the boards according to size, quality, and kind of wood.

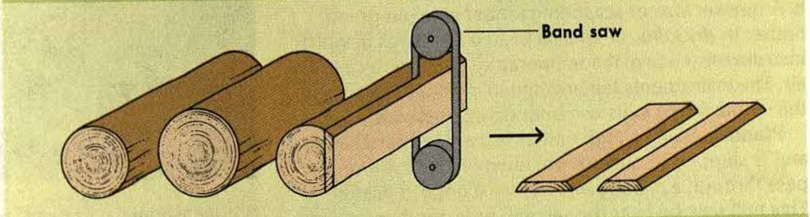
Timber is graded differently in different countries or groups of countries. For example, the Scandinavian system, widely accepted in Europe, has six grades for sawed wood, the first four of which—the best—are lumped together as "U.S." (unsorted); Grades 5 and 6 are for inferior timber, which is used as packing material. In the United States, there are eight grades to classify hardwood: *firsts, seconds, selects, No. 1 common, No. 2 common, sound wormy, No. 3 A common,* and *No. 3B common.* Softwood is graded from *selects* in grades A to D down to *common dimensions* grade 4. In ASEAN countries (the Asia Pacific region), detailed grading standards for logs, sawed wood, veneer, and plywood use a series of "systems": the *defect system,* the *pure defect system,* the *yield system,* and so on, which specify characteristics such as the proportion of a log that must be sound, the size and concentration of bore holes, the *bowing* (bend) in a log; faults such as knots, splits, bumps, and wounds; and where on the log they occur. There are tables for the yield ratio and formulae for calculating the defective volume.

How a sawmill saws large logs into timber

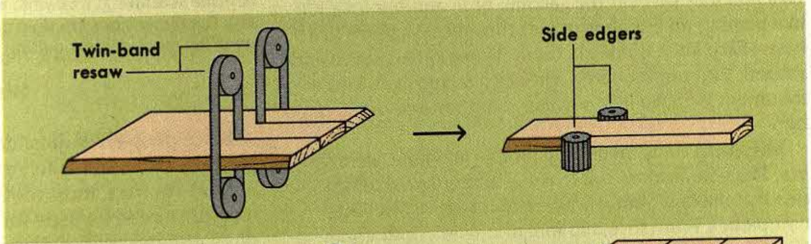
A circular saw cuts large logs into shorter lengths in a process called *crosscutting.* Before the logs reach the saw, a mechanical debarker strips them of their bark.



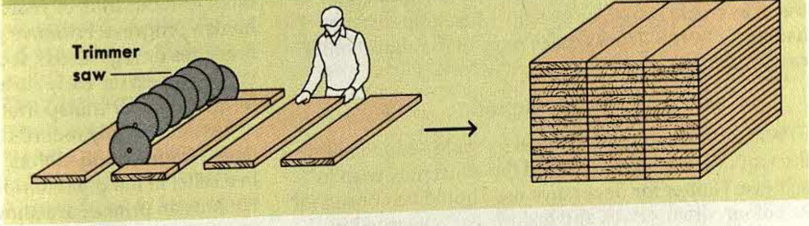
A headsaw slices each log into boards or other pieces of timber. The headsaw shown in the diagram is a *band saw,* an endless steel belt that runs on two pulleys. The teeth of the saw are on an edge of the belt.



A resaw cuts timber to its proper width and thickness. The timber then goes through *side edgers.* These devices remove the rough edges and make the sides straight and even.

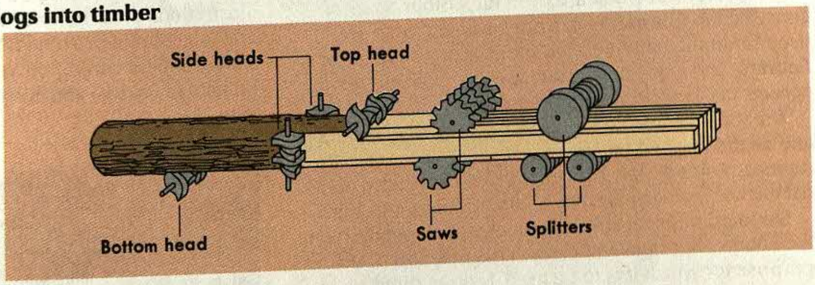


A trimmer saw cuts timber to standard lengths and makes the ends square. Next, workers called *graders* sort the timber according to size, quality, and kind of wood. The timber is then stacked outdoors to dry.



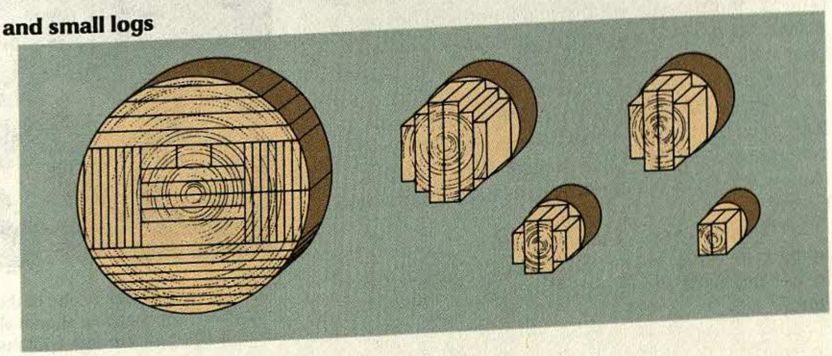
How a sawmill saws small logs into timber

A chipper-canter, *right,* saws small logs. This machine has rotating *heads* (knives) that chip wood from the top, bottom, and sides of logs. A set of circular saws cuts each log into rectangular pieces called *cants.* Devices called *splitters* then separate the cants.



Patterns for sawing large and small logs

Log-sawing patterns vary, depending on the size of the log. Mills manufacture as much timber as possible from each log. The diagram shows several patterns that may be used to saw large and small logs.



Seasoning timber means removing excess moisture from the wood. More than half the weight of green timber may come from moisture in the wood. After seasoning, less than a tenth of the weight of the timber may come from moisture. Mills also ship timber without seasoning. But for most uses the moisture must be removed so that the wood does not warp. In the process, the wood shrinks in size.

Mills sometimes season timber by *air drying.* Workers stack the wood outdoors to let the sun and wind dry it. A quicker way of seasoning timber is to put green timber in *dry kilns,* or special heated buildings in which instruments control the temperature and moisture of the air. The instruments tell how much moisture remains in the wood. Some mills use both drying methods.

Planing. Some rough timber is used in construction and is shipped to dealers. But most of the timber must pass through a *planing mill* before it goes to market. This mill may be near the sawmill or in another location. In a planing mill, timber passes through machines that have sharp knife blades in them. These knives shave and smooth the rough boards. Timber also receives further treatment to make it into dressed timber or worked timber.

Shipping. Most mills ship timber to wholesale dealers. The wholesalers sell to retail timberyards, to factories that make wooden articles, and to construction companies. From forest to mill to retailer, timber may travel by truck, by rail, or by ship. Most long-distance hauling is by rail. Trucks make most of the short timber-carrying trips.

Buying timber

When selecting timber, buyers should keep in mind the work they want it to do and the effect they wish to achieve. Timber for decorative use should be chosen for its colour, grain, knots, and texture. For construction purposes, strong and durable timber should be used. Different kinds of wood are used for various types of construction. For example, Douglas fir and pine are used for home building. Oak and teak are popular for flooring, and many coniferous species, such as Norway spruce, make good weatherboarding.

Timber is measured before it is seasoned and planed, and so the finished pieces are actually smaller than the *nominal* (named) size. Timber with a 5-centimetre nominal thickness is actually only about 4 centimetres thick.

Standard nominal sizes of timber vary depending on the country of origin and on the type of wood or the purpose for which it is to be used. Mills cut timber into a variety of widths and lengths. Standards lay down the range of thicknesses, widths, and lengths of boards, planks, *flitches* (slabs of timber), and *balks* (beams). A board, for instance, may be specified as: width, 15 centimetres and up; length, 2 metres and up; thickness, 0.5 to 5 centimetres. A plank would have the same width and length, but its thickness may be specified as 5.5 to 10 centimetres. There are also specifications for other shapes and types of timber, such as panels, strips and sleepers.

In the United States and some other countries, a traditional system is used, in which the timber is measured in feet and inches and generally priced by the *board foot.*

A laser scanner at a sawmill gives the exact dimensions of a log. The dimensions are then entered into a computer to determine the most efficient cutting to yield the most planks.

History

Since people's earliest days on earth, forests have played a vital part in life. At first, forests were a source of food—berries, nuts, roots, and wild animals. Later, forests came to be used for fuel, implements, and weapons. For thousands of years, forests have contributed to human progress. Primitive people built homes out of branches or logs. Cross sections cut from logs served as crude wheels for early carts. Logs fastened together formed rafts for transportation.

There are many records of timber working in ancient times, from writing-tablets, inscriptions, and sculptures. In a relief in the great temple at Karnak in Ancient Egypt, Phoenician princes are shown felling trees for the Egyptian conqueror. Another sculpture in an Assyrian palace shows large logs being transported by sea. But the best illustrations of timber-working in ancient times are on Trajan's column in Rome (113 A.D.). The illustrations show soldiers cutting down trees, carrying timber, building a bridge, and constructing the wooden walls of their camp.

Removing the bark is one of the first steps in preparing logs for timber. The machine shown above, called a log debarker, rubs or chips off the bark with metal bars or knives.

Logs are taken to sawmills to be cut up for timber. Pine logs from specially established plantations provide softwood, *above,* for Australia's building industry.

Timber does not survive as well as pottery or metal. Unless it is in a dry climate or sealed from the atmosphere, it disintegrates. Excavations of Ancient Egyptian tombs have produced wooden statues, furniture, and other objects, which, when analysed, show the use of native and imported timber over a period of more than 3,000 years. Water is also a good preserver of timber. Underwater archaeology has contributed greatly to our knowledge of ancient timber. The *Mary Rose,* flagship of King Henry the Eighth of England, was raised from the sea in 1982, after more than 400 years underwater. Most of its structural timberwork was intact. Another famous sunken ship is the *Wasa,* which went down in 1628 near Stockholm, Sweden and was raised in 1961.

The first manufactured boards were probably produced over a sawpit, where one person stood beneath and another above the log, at either end of a two-handed saw. The earliest sawmills were crude water-powered mills. Steam power replaced water power during the Industrial Revolution in the early 1800's.

Today, as in the past, houses, furniture, boats, and many other items are made of wood. Many products of past times have been replaced, and new materials have been invented, but wood is even more essential today. Growing populations need more housing, and the construction industry uses more timber than any other industry. For example, China's imports of industrial roundwood doubled in the 11 years from 1977 to 1988 from 7 million to 14 million cubic metres. In the same period, Europe's imports of the same material rose by more than 9 million cubic metres.

Related articles in *World Book* include:

Carpentry
Forest products
Forestry
House
Plywood
Rot
Tree
Veneer
Wood
Woodworking

Outline

I. Kinds of timber
- A. Softwood timber
- B. Hardwood timber

II. From forest to sawmill
- A. Cutting down trees
- B. Transporting logs

III. From sawmill to timberyard
- A. Sawing logs
- B. Grading timber
- C. Seasoning timber
- D. Planing
- E. Shipping

IV. Buying timber

V. History

Questions

What is the most important use of timber?
How do fellers aim a tree?
What is high-lead logging?
Why must logs be washed before they are sawed?
How may timber be seasoned?
What is a *board foot*?
How does softwood differ from hardwood?
What two kinds of wood are the most important in home building?

Timbuktu (pop. 20,483) is a small trading town in central Mali. Its official name is Tombouctou. From the 1200's to the 1500's, it was one of the richest commercial cities of Africa and a centre of Muslim learning.

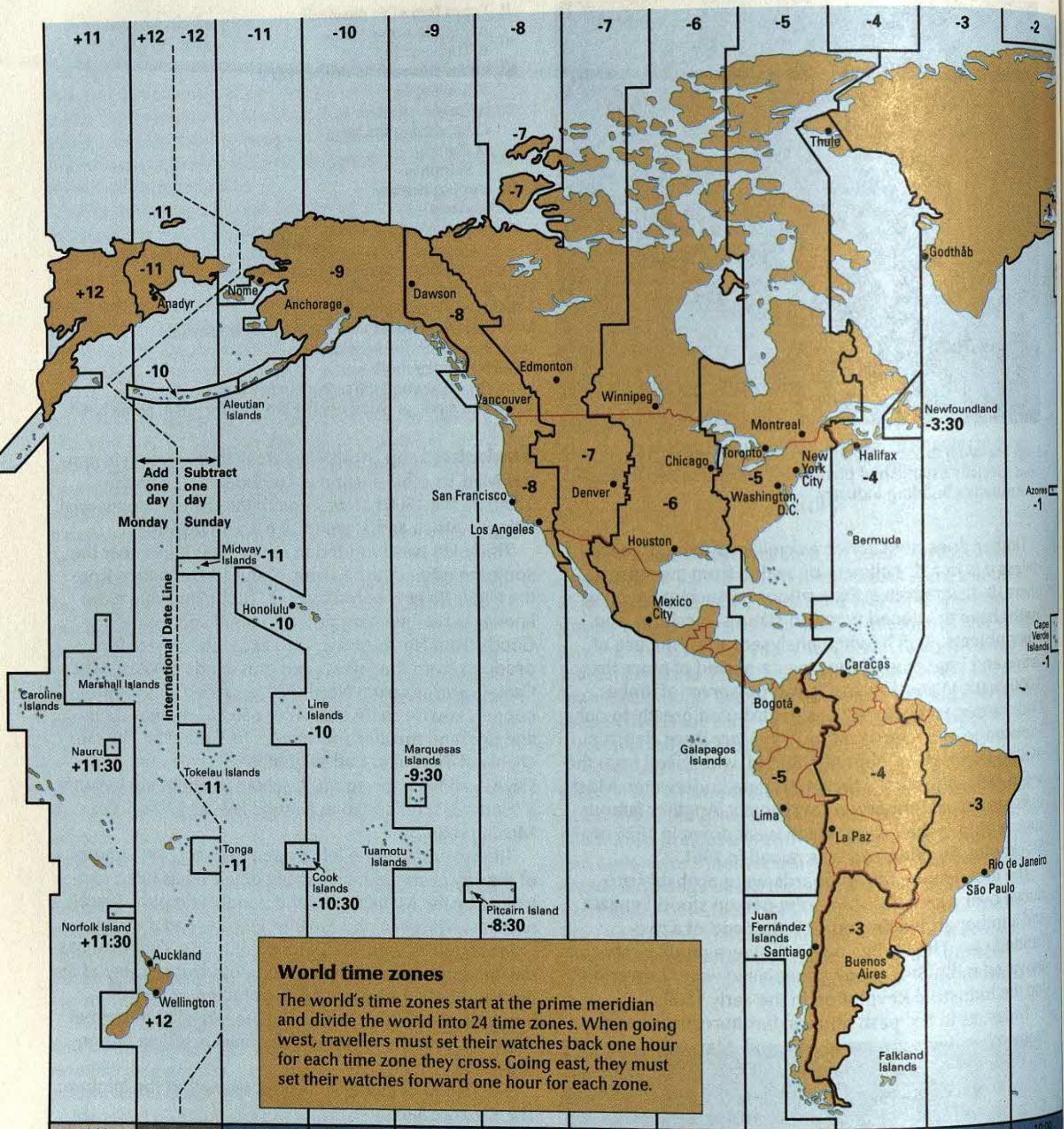
Timbuktu was founded in about 1100. It lies near the southern edge of the Sahara, about 13 kilometres from the Niger River (see **Mali** [map]). Timbuktu came to be known as the "meeting point of camel and canoe." Goods from North Africa were exchanged there for products from the forests and grasslands of West Africa. Camel caravans from North Africa carried salt, cloth, copper, cowrie shells that were used as money, dates and figs, and metal manufactures to Timbuktu. The merchants of Timbuktu traded gold, ivory, kola nuts, and slaves—all from the south. A school in Timbuktu became a centre of scholarship in history, law, and Islam, the Muslim religion.

Timbuktu's location left it open to attack, and control of the city changed hands many times. It has been controlled by the Mali Empire, the Songhai Empire, Tuareg nomads, Morocco, the Tukulor Empire, and then by France from 1893 to 1960. Since the 1600's, Timbuktu has declined in both importance and population. Many of its mud and brick buildings have crumbled or lie half-buried in the shifting sands. But the arrival of the camel caravans from the northern salt mines is still an important event.

See also **Mali** (picture); **World, History of the** (picture; The Sankore Mosque).

Time is one of the world's deepest mysteries. No one can say exactly what it is. Yet, the ability to measure time makes our way of life possible. Most human activities involve groups of people acting together in the same place at the same time. People could not do this if they did not all measure time in the same way.

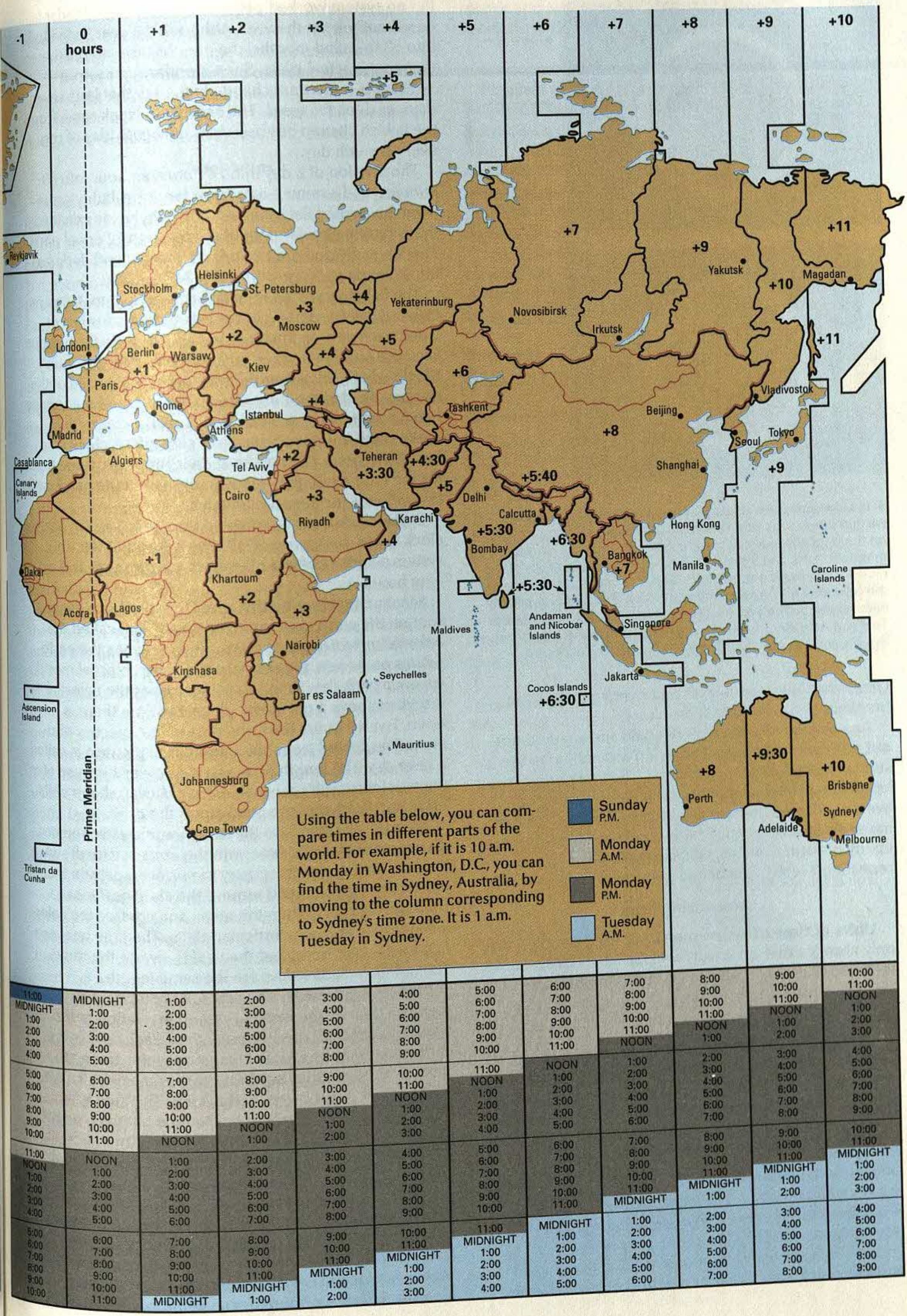
One way of thinking about time is to imagine a world without time. This timeless world would be at a standstill. But if some kind of change took place, that timeless world would be different "now" than it was "before." The period—no matter how brief—between "before" and "now" indicates that time must have passed. Thus, time and change are related because the passing of time depends on changes taking place. In the real world, changes never stop happening. Some changes seem to happen only once, like the falling of a particular leaf.



World time zones

The world's time zones start at the prime meridian and divide the world into 24 time zones. When going west, travellers must set their watches back one hour for each time zone they cross. Going east, they must set their watches forward one hour for each zone.

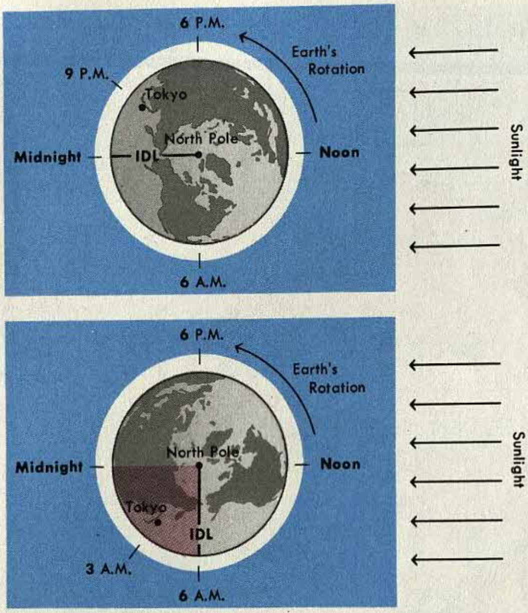
11:00	NOON	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00
NOON	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	MIDNIGH
2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	MIDNIGHT	1:00
3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	MIDNIGHT	1:00	2:00
4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	MIDNIGHT	1:00	2:00	3:00
5:00	6:00	7:00	8:00	9:00	10:00	11:00	MIDNIGHT	1:00	2:00	3:00	4:00
6:00	7:00	8:00	9:00	10:00	11:00	MIDNIGHT	1:00	2:00	3:00	4:00	5:00
7:00	8:00	9:00	10:00	11:00	MIDNIGHT	1:00	2:00	3:00	4:00	5:00	6:00
8:00	9:00	10:00	11:00	MIDNIGHT	1:00	2:00	3:00	4:00	5:00	6:00	7:00
9:00	10:00	11:00	MIDNIGHT	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00
10:00	11:00	MIDNIGHT	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00
11:00	MIDNIGHT	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00
MIDNIGHT	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	NOON
2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	NOON	1:00
3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	NOON	1:00	2:00
4:00	5:00	6:00	7:00'	8:00	9:00	10:00	11:00	NOON	1:00	2:00	3:00
5:00	6:00	7:00	8:00	9:00	10:00	11:00	NOON	1:00	2:00	3:00	4:00
6:00	7:00	8:00	9:00	10:00	11:00	NOON	1:00	2:00	3:00	4:00	5:00
7:00	8:00	9:00	10:00	11:00	NOON	1:00	2:00	3:00	4:00	5:00	6:00
8:00	9:00	10:00	11:00	NOON	1:00	2:00	3:00	4:00	5:00	6:00	7:00
9:00	10:00	11:00	NOON	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00
10:00	11:00	NOON	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00



Using the table below, you can compare times in different parts of the world. For example, if it is 10 a.m. Monday in Washington, D.C., you can find the time in Sydney, Australia, by moving to the column corresponding to Sydney's time zone. It is 1 a.m. Tuesday in Sydney.

▇	Sunday P.M.
▒	Monday A.M.
▓	Monday P.M.
░	Tuesday A.M.

-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10
11:00 MIDNIGHT 1:00 2:00 3:00 4:00	MIDNIGHT 1:00 2:00 3:00 4:00 5:00	1:00 2:00 3:00 4:00 5:00 6:00	2:00 3:00 4:00 5:00 6:00 7:00	3:00 4:00 5:00 6:00 7:00 8:00	4:00 5:00 6:00 7:00 8:00 9:00	5:00 6:00 7:00 8:00 9:00 10:00	6:00 7:00 8:00 9:00 10:00 11:00	7:00 8:00 9:00 10:00 11:00 NOON	8:00 9:00 10:00 11:00 NOON 1:00	9:00 10:00 11:00 NOON 1:00 2:00	10:00 11:00 NOON 1:00 2:00 3:00
5:00 6:00 7:00 8:00 9:00 10:00	6:00 7:00 8:00 9:00 10:00 11:00	7:00 8:00 9:00 10:00 11:00 NOON	8:00 9:00 10:00 11:00 NOON 1:00	9:00 10:00 11:00 NOON 1:00 2:00	10:00 11:00 NOON 1:00 2:00 3:00	11:00 NOON 1:00 2:00 3:00 4:00	NOON 1:00 2:00 3:00 4:00 5:00	1:00 2:00 3:00 4:00 5:00 6:00	2:00 3:00 4:00 5:00 6:00 7:00	3:00 4:00 5:00 6:00 7:00 8:00	4:00 5:00 6:00 7:00 8:00 9:00
11:00 NOON 1:00 2:00 3:00 4:00	NOON 1:00 2:00 3:00 4:00 5:00	1:00 2:00 3:00 4:00 5:00 6:00	2:00 3:00 4:00 5:00 6:00 7:00	3:00 4:00 5:00 6:00 7:00 8:00	4:00 5:00 6:00 7:00 8:00 9:00	5:00 6:00 7:00 8:00 9:00 10:00	6:00 7:00 8:00 9:00 10:00 11:00	7:00 8:00 9:00 10:00 11:00 MIDNIGHT	8:00 9:00 10:00 11:00 MIDNIGHT 1:00	9:00 10:00 11:00 MIDNIGHT 1:00 2:00	10:00 11:00 MIDNIGHT 1:00 2:00 3:00
5:00 6:00 7:00 8:00 9:00 10:00	6:00 7:00 8:00 9:00 10:00 11:00	7:00 8:00 9:00 10:00 11:00 MIDNIGHT	8:00 9:00 10:00 11:00 MIDNIGHT 1:00	9:00 10:00 11:00 MIDNIGHT 1:00 2:00	10:00 11:00 MIDNIGHT 1:00 2:00 3:00	11:00 MIDNIGHT 1:00 2:00 3:00 4:00	MIDNIGHT 1:00 2:00 3:00 4:00 5:00	1:00 2:00 3:00 4:00 5:00 6:00	2:00 3:00 4:00 5:00 6:00 7:00	3:00 4:00 5:00 6:00 7:00 8:00	4:00 5:00 6:00 7:00 8:00 9:00



The time and date at any place on the earth change as the earth rotates on its axis. When the International Date Line (IDL) is on the opposite side of the earth from the sun, *top diagram,* it is midnight there and 9 p.m. in Tokyo. At this instant, every place on the earth has the same date. Six hours later, *bottom diagram,* the positions of places on the earth have changed appreciably with respect to the sun. It is then 6 a.m. at the IDL and 3 a.m. in Tokyo. A new day, *shown in red,* has begun in the area between the IDL and the *meridian* (line of longitude) for midnight.

Other changes happen over and over again, like the breaking of waves against the shore.

Any change that takes place again and again stands out from other changes. The rising and setting of the sun are examples of such change. The first people to keep time probably counted such natural repeating events and used them to keep track of events that did not repeat. Later, people made clocks to imitate the regularity of natural events. When people began to count repeating events, they began to measure time.

Measuring time

Units of time measurement. For early peoples, the only changes that were truly regular—that is, repeated themselves evenly—were the motions of objects in the sky. The most obvious of these changes was the alternation of daylight and darkness, caused by the rising and setting of the sun. Each of these cycles of the sun came to be called a *day.* Another regular change in the sky was the change in the visible shape of the moon. Each cycle of the moon's changing shape takes about 29½ days, or a *month.*

The cycle of the seasons gave people an even longer unit of time. By watching the stars just before dawn or after sunset, people saw that the sun moved slowly eastward among the stars. The sun appeared to make a full circle around the sky in one cycle of the seasons. This cycle takes about 365¼ days, or a *year.*

For hundreds of years, people tried to fit days and months evenly into a year or a period of several years. But no system worked perfectly. Today, the calendar is based entirely on the year. Although the year is divided into 12 so-called months, the months have no relation to the moon's actual cycle. See **Calendar.**

There is no regular change in the sky that lasts seven days, as does the *week.* The seven-day week came from the Jewish custom of observing a *Sabbath* (day of rest) every seventh day.

The division of a day into 24 *hours,* an hour into 60 *minutes,* and a minute into 60 *seconds* probably came from the ancient Babylonians. The Babylonians divided the apparent circular path of the sun into 12 equal parts. Then they divided the periods of daylight and darkness into 12 parts each, resulting in a 24-hour day.

The Babylonians also divided the circle into 360 parts called *degrees.* Other ancient astronomers further divided each degree into 60 minutes. Later, clocks became accurate enough to need smaller units than the hour. Clockmakers, following the astronomers' division of the degree, divided the hour into 60 minutes and the minute into 60 seconds. In this way, the face of a clock could easily show hours, minutes, and seconds. A clock face has 12 divisions. Each of these divisions equals one hour for the hour hand, five minutes for the minute hand, and five seconds for the second hand.

Some clock faces are divided into 24 hours. On such a clock, 9 a.m. is shown as 0900 and 3 p.m. as 1500. This system avoids confusion between the morning and evening hours.

Measuring time by the sun. Directly above every spot on the earth, an imaginary curved line called the *celestial meridian* passes through the sky. As the earth rotates on its axis, the sun crosses every celestial meridian once each day. When the sun crosses the celestial meridian above a particular place, the time there is noon. Twelve hours later, the time at that place is midnight. The period from one midnight to the next is called a *solar day.* The length of a solar day varies because of the tilt of the earth's axis, the *elliptical* (oval) shape of its orbit, and its changing speed along the orbit.

To make all solar days the same length, astronomers do not measure solar time with the *apparent* (real) sun. Instead, they use an imaginary *mean* (average) sun that moves at a steady speed around the sky. *Local mean solar noon* occurs when the mean sun crosses the celestial meridian above a particular place. The time between one mean solar noon and the next is always the same. Thus, all *mean solar days* are the same length.

Measuring time by the stars. Astronomers also measure time by the earth's rotation in relation to the stars. This time is called *sidereal time.* Each day, as the earth rotates on its axis, an imaginary point among the stars called the *vernal equinox* crosses the celestial meridian above every place on the earth. The time when this happens is *sidereal noon.* The time between one sidereal noon and the next is one *sidereal day.* A sidereal day is shorter than a mean solar day by 3 minutes and 56 seconds. See **Star** (Measuring time).

Devices that measure time. The *sundial* was one of the earliest devices for measuring time. But it can work only in sunshine. Early peoples also used ropes with knots tied at regular intervals or candles marked with regularly spaced lines. When burned, such devices measured time. An *hourglass* or *sandglass* tells time by means of sand trickling through a narrow opening. A *water clock,* or *clepsydra,* measures time by allowing water to drip slowly from one marked container into another. By the 1700's, people had developed clocks and watches that told time to the minute. Modern electronic and atomic clocks can measure time with far greater accuracy. See **Measurement** (Measuring time).

Time zones

Local and standard time. Clocks in various parts of the world do not all show the same time. Suppose they all did show the same time—3 p.m., for example. At that time, people in some countries would see the sun rise, and people in other lands would see it high in the sky. In still other countries, the sun could not be seen because 3 p.m. would occur at night. Instead, clocks in all locations show 12 o'clock at midday.

Every place on the earth that is east or west of another place has noon at a different time. The time at any particular place is called the *local time* of that place. At noon local time in one town, the time might be 11 a.m. in another place west of the town or 1 p.m. in a place to the east. The local time in the other places depends on how far east or west they are from the town.

If every community used a different time, travellers would be confused and many other problems would be created. To avoid all such problems, *standard time zones* were established. These zones were set up so there would be a difference of one hour between a place on the eastern edge of a time zone and a place on the western edge if each were on its own local time. But under the time zone system, each of these places is not on its own local time. The local time at the *meridian* (line of longitude) that runs through the centre of the zone is used by all places within the zone. Thus, time throughout the zone is the same.

Worldwide time zones were established in 1884. The meridian of longitude passing through the Greenwich Observatory in England was chosen as the starting point for the world's time zones. The Greenwich meridian is often called the *prime meridian.* The mean solar time at Greenwich is called *Greenwich Mean Time* (GMT) or *Greenwich Civil Time* (GCT).

An international conference in 1884 set up 12 time zones west of Greenwich and 12 to the east. These zones divide the world into 23 full zones and two half zones. The 12th zone east and the 12th zone west are each half a zone wide. They lie next to each other and are separated by an imaginary line called the *International Date Line.* The line is halfway around the world from Greenwich. A traveller crossing this line while heading west, toward China, loses a day. A traveller who crosses it travelling eastward gains a day. A few places do not use standard time zones. For example, the polar regions have weeks of constant sunlight or darkness.

In the 1940's, experts began to realize that time based on astronomical measurements was not completely smooth, since the earth slowed down and speeded up in an irregular fashion. As a result, in 1958, the length of the second was redefined in terms of the natural vibration frequency of the caesium atom. However, the length of the year continued to be determined from astronomical observations. This time scale based on both atomic and astronomical measurements is called *Universal Time Coordinated* (UTC).

Scientific ideas about time

Physical time. Scientists think of time as a fundamental quantity that can be measured. Other fundamental quantities include length and mass. The noted physicist Albert Einstein realized that measurements of these quantities are affected by *relative motion* (motion between two objects). Because of his work, time became popularly known as the *fourth dimension.* See **Relativity** (Special theory); **Fourth dimension.**

Many physicists believe that the apparent nonstop, forward flow of time is not a property of the basic laws of nature. They consider it a result of the fact that the universe is expanding and becoming more disorganized. Some physicists have considered the possibility that, under certain circumstances, time might flow backward. But experiments have not supported this idea.

Biological time. The activities of many plants and animals are timed to the cycle of day and night. These natural rhythms are called *circadian rhythms.* The most obvious example is the sleep cycle.

Many plants and animals are sensitive to other natural time cycles. Certain plants do not start their next step of growth until daylight each day lasts a certain time. Some sea animals time their activities to the changing tides. These creatures even seem to know such times away from their home waters.

Geological time. Geologists have found clues in the earth's crust that indicate how many billions of years ago it was formed. One of these indicators is the element uranium. Uranium changes slowly into the element lead by means of radioactive decay. By measuring the amount of lead in a sample of uranium ore, scientists can estimate when the rock was formed.

A second clue to geological time is radioactive carbon. This form of carbon is absorbed by every living plant and animal. The rate of the carbon's decay can help a geologist estimate how long ago the plant or animal died. See **Radiocarbon.**

Related articles. See **Calendar** and **Clock** with their lists of *Related articles.* Other related articles include:

Biological clock
Day
Daylight saving
Greenwich Meridian
Hour
International Date Line
Meridian
Radiogeology
Ship (Nautical terms [Ship's bell])
Sidereal time
Standard time
Weights and measures

Time lock. This type of combination lock cannot be opened before a certain hour to which the lock has been set. There are two general types of time locks. The first kind is used mainly in bank vaults. This lock is set to a certain hour. At that hour, but at no other time, the lock can be opened by dialling the combination.

The second type of time lock is called a time-recording lock. It has several keys. When the lock is opened, it registers the number of the key and the time that the lock was opened.

Time zone. See **Time** (Time zones; map).

Timed-release medicine. See **Microencapsulation.**

Timor is an island in Southeast Asia. For location, see **Asia** (political map). Timor covers 31,000 square kilometres and has a population of about 2 million.

The western half of Timor has been part of Indonesia since that country was formed in 1949. The eastern half became a territory of Portugal in the 1500's. In 1975, Timorese people there demanded independence from Portugal. Fighting broke out among groups of Timorese who wanted to control the territory. The Portuguese rulers left eastern Timor. Later in 1975, Indonesian troops occupied eastern Timor. In 1976, Indonesia claimed the region and declared it an Indonesian province. For several years, fighting occurred off and on between Timorese guerrillas and the Indonesian troops. Eastern Timor suffered food shortages and many people died from starvation. In 1991, Indonesian troops fired on mourners at the funeral of a youth killed by security forces. About 180 people died following the funeral. In 1994, about 20 people were killed when the authorities broke up a student demonstration.

Timothy was one of the friends of Saint Paul. He was probably born in Lystra, in Asia Minor. His father was Greek and his mother was Jewish (Acts 16:1, II Timothy 1: 5). He is thought to have been converted to Christianity when Paul made his first missionary journey and talked with him. However, Paul never discusses their first meeting and Timothy is said to be a "disciple" when he met Paul at Lystra (Acts 16:1-3). Timothy joined Paul on his second journey and is said to have been his trusted friend and companion until Paul's death. Later, he took Paul's place as bishop of the church of Ephesus. It is believed he died as a martyr, in about A.D. 100.

The First and Second Epistles to Timothy and the Epistle to Titus are known as the Pastoral Epistles. This is because they contain advice to pastors concerning church government, church officers, teaching, and Christian faithfulness and endurance. Critics debate whether or not Paul wrote these epistles. Some believe that a later author wrote them, using Paul's ideas. This would explain why the Pastoral Epistles do not give much information about the character and deeds of the original Timothy. The epistles may have been written between A.D. 90 and 110, or even later.

Timothy, also called *meadow grass,* is a grass crop grown primarily for hay. It grows in tufts about 50 to 100 centimetres high. The slender, leafy stems bear round spikes of tiny, tightly packed flowers. Timothy is a cool season plant native to northern Europe and Asia.

Timothy is a *perennial*—that is, it grows year after year without replanting. However, the crop does not live long if animals graze on it continually, or if it is harvested in an immature stage. The quality of timothy hay is improved when the plant is grown with clover or alfalfa. In some countries, the first cutting of timothy is frequently harvested for hay or silage. Later cuttings are left in the pasture for grazing.

Timothy is widely grown in temperate areas.

Scientific classification. Timothy is a member of the grass family, Gramineae (Poaceae). It is *Phleum pratense.*

See also **Grass** (picture: Common grasses).

Timur the Lame. See **Tamerlane.**

Tin is a chemical element with symbol Sn. It is a white metal that people have used since ancient times. The earliest known use of tin occurred about 3500 B.C. in the city of Ur in southern Mesopotamia (now Iraq). The people of Ur made articles from bronze, an alloy of tin and copper. Today, tin is used chiefly in the production of *tin plate.* Tin plate consists of steel coated on both sides with an extremely thin film of tin. Most tin plate is made into tin cans for packaging food and other products.

The atomic number of tin is 50, and its atomic weight is 118.71. At 20° C, tin has a density of 7.2984 grams per cubic centimetre (see **Density**). The difference between its melting point, 231.9° C, and its boiling point, 2270° C, is one of the widest of any metal. Tin is also very *malleable*—that is, it can easily be formed into complex shapes. These and other properties of tin enable it to be used in the manufacture of a wide variety of products.

Uses. The coating on tin cans protects the steel in the cans from rust and provides an attractive appearance. Tin also prevents the weak acids in food from damaging the inside of the cans. See **Tin can.**

Tin coatings also protect many other items. Most paper clips, safety pins, straight pins, and staples are made of steel or brass coated with tin. Many food-preparation containers and utensils have tin coatings.

The second most important use of tin is in *solders,* which are alloys used to join metal surfaces. Solders made primarily of tin and lead are called *soft solders* and melt at relatively low temperatures. Other important tin alloys include bronze and pewter. See **Solder; Bronze; Pewter.**

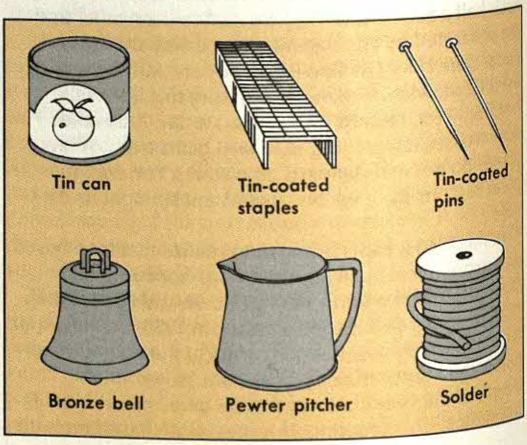
The malleability of tin enables manufacturers to make tin into extremely thin foil. One use for such foil is as a moistureproof wrapping. *Terneplate* is iron coated with an alloy of lead and tin. Sheets or strips of terneplate are used for roofing and in making such products as fuel tanks and fire extinguishers.

Manufacturers improve the properties of various metals by adding small amounts of tin. For example, cast iron that contains only 0.1 per cent tin is much more durable and easier to work with than ordinary cast iron. Many other products, including bearings, dental fillings, and printing alloys, also contain small amounts of tin.

Tin combines with other elements to form a great number of useful compounds. Many toothpastes contain *stannous fluoride,* a compound of tin and fluorine that helps prevent tooth decay. Certain compounds that contain tin and carbon are used as pesticides.

How tin is used

Tin's unusual chemical and physical properties enable it to be used in a wide variety of products for the home and industry.

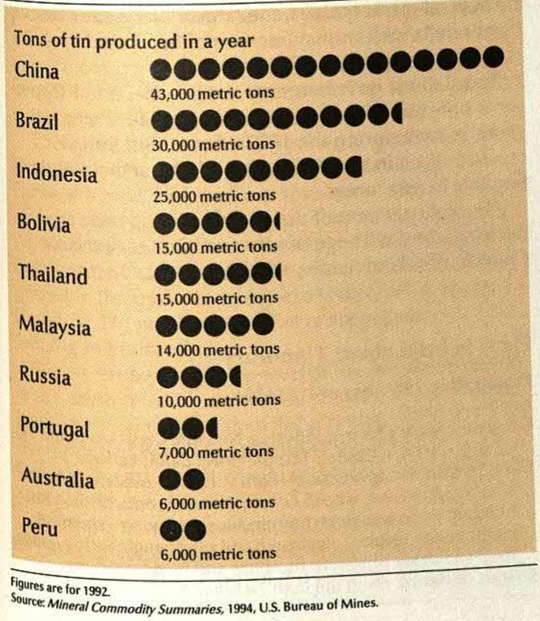


A tin mine near Kuala Lumpur provides tin ore for refining. Malaysia is one of the world's leading producers of tin.

Where tin is found. Tin makes up only about 0.001 per cent of the earth's crust. As a result, the amount of tin mined annually is very small compared with other common metals. Most known deposits of tin are in the Southern Hemisphere.

The principal tin ore is a compound of tin and oxygen called *cassiterite* (see **Cassiterite**). Some tin ores contain sulphur and small amounts of such other metals as copper, iron, and lead. Tin deposits sometimes occur as narrow veins that run through granite. Most tin ore, however, is found in plains, where flowing water has deposited bits of eroded granite and ore.

Leading tin-mining countries



Figures are for 1992.
Source: *Mineral Commodity Summaries,* 1994, U.S. Bureau of Mines.

China is the world's leading producer of tin. Other important tin-producing countries include Australia, Bolivia, Brazil, Indonesia, Malaysia, Peru, Portugal, Russia, and Thailand.

Refining tin. Processors produce tin by heating cassiterite with coal and limestone in a special furnace. After this process, called *smelting,* the processors refine the tin—usually to a purity of 99.8 per cent. For details on refining, see **Metallurgy** (Extractive metallurgy). Most pure tin is cast into *ingots* (bars) that weigh about 45 kilograms.

Tin can is a container used for packaging, transporting, and marketing hundreds of food and nonfood items for home and industry. Most tin cans are made of steel covered with a thin coating of tin. But millions of cans contain no tin at all and many are made entirely of aluminium. The first tin cans were handmade and sealed with solder. Today, manufacturers make and seal them on a series of machines called a *can line* that produces more than 500 a minute. The shape, size, and construction of cans differ to meet the specific need of the product they contain. But cylindrical cans are most commonly used.

Many tin cans have enamel on the inside to prevent discoloration of the food. Perishable foods are preserved by heating the sealed can. In 1963, an inventor from Ohio, U.S.A., received a patent on a "tab-opening" tin can. The user opens the can by pulling off a strip of aluminium on top. In the 1960's, steel companies began making *thin tin* for tin cans. It is thinner and lighter than the usual tin plate used in tin cans. See also **Food preservation** (Canning).

Tinamou is a ground-living bird. There are 47 species, all of which live in South America. Tinamous have brownish feathers, dark above and paler below. Their short wings and strong legs make them well suited for life on the ground, and they rarely fly. They grow to between 20 and 50 centimetres. Tinamous feed on seeds, berries, and insects. They nest on the ground. A female tinamou may lay 12 or more eggs in the breeding season. Both eggs and young are cared for by the male.

Scientific classification. Tinamous belong to the tinamou family, Tinamidae.

Tinaroo Falls Dam blocks the Barron River near Kairi on the Atherton Tableland in north Queensland, Australia. The dam is 10 kilometres from Atherton and 100 kilometres from the mouth of the river. It was built between 1953 and 1958 at a location 3 kilometres above Tinaroo Falls. The dam measures 525 metres in length, and its crest rises 47 metres above the lowest part of its foundations. The storage capacity of the artificial lake is 407,100,000 cubic metres. The lake covers nearly 34 square kilometres. The stored water is used to irrigate mixed farms.

Tinbergen, Jan (1903-1994), a Dutch economist, shared the first Nobel Prize for economics with Ragnar Frisch of Norway in 1969. Tinbergen and Frisch received the award for their work on the development of mathematical models used in *econometrics* (mathematical analysis of economic activity).

Tinbergen was born in The Hague, the Netherlands, and graduated from the University of Leiden. In 1933, he became a professor at the Netherlands School of Economics in Rotterdam. From 1936 to 1938, he worked with the League of Nations and developed the first econometric model of a national economy. He served with the Dutch government's Central Bureau of Statistics and its Central Planning Bureau. In 1955, Tinbergen became an adviser to other governments and international organizations. He became chairman of the United Nations Committee for Development Planning in 1965.

Tinbergen, Nikolaas (1907-1988), was a Dutch-born zoologist who studied how the behaviour of animals is adapted to their environment. He also investigated the evolution of this behaviour over millions of years by comparing the actions of various species. Tinbergen shared the 1973 Nobel Prize for physiology or medicine with Austrian naturalists Konrad Lorenz and Karl von Frisch. They received the award for their studies of animal behaviour. Tinbergen worked with birds, butterflies, fish, wasps, and other animals in their natural surroundings. His best-known research concerns the social behaviour of gulls. Tinbergen also applied ideas about animal behaviour to the behaviour of children suffering from a developmental disorder called *autism.*

Tinbergen, the brother of economist Jan Tinbergen, was born in The Hague. He earned a doctorate from Leiden University in 1932. Tinbergen worked at Oxford University in England from 1949 until his death. His books include *The Herring Gull's World* (1953) and *The Animal in Its World* (1972, 1973). He was co-author of *Autistic Children: New Hope for a Cure* (1983).

Ting, Samuel Chao Chung (1936-), an American-born Chinese scientist, was awarded the Nobel Prize for physics in 1976. He shared the prize with Burton Richter, an American scientist. The award was made for their discovery of an elementary nuclear particle called the *psi* or *J, particle.*

Ting, also known as *Ding Zhaozhong,* was born in Michigan in the United States. He spent his early years in mainland China and Taiwan. In 1967, he became a professor of physics at the Massachusetts Institute of Technology. Later he worked at the European Organization for Nuclear Research (CERN) in Geneva in Switzerland, and at the University of Columbia in the United States.

Tinnitus is the sensation of hearing sounds that seem to come from within the head. Most people with tinnitus hear ringing, buzzing, or hissing noises. Others hear sounds like a cricket's chirping or the ocean's roar. The noise may be continuous or come and go. It may be heard in one or both ears. Tinnitus can be extremely distracting, and in some cases it is loud enough to keep the person awake. Many victims also have some hearing loss, ear ache, or dizziness.

Some cases of tinnitus can be traced to a specific condition, such as a blocked ear canal, an ear infection, or the use of certain medicines. Other cases of tinnitus can be traced to blood vessel disease, head injury, aging, and exposure to loud noises. However, in most cases of tinnitus, no cause can be identified. Doctors suspect that such cases are due to abnormal functioning of the inner ear or its nerve connections to the brain. When doctors can identify the cause of a person's tinnitus, they often can relieve it by treating the underlying condition. In cases with no obvious cause, certain medicines or surgical procedures may reduce the noise. Some people who suffer from tinnitus use a device that is similar to a hearing aid, which masks the noise with more pleasant sounds.

Tintoretto (1518-1594) was a Venetian painter during the late Italian Renaissance. He became a leading artist of the period for the churches and wealthy families of Venice, Italy.

Tintoretto created works noted for their dramatic action. His paintings show the influence of the rich colours used by Titian and the vigorous, muscular forms drawn by Michelangelo. Tintoretto achieved a unique style through exaggeration. He sometimes distorted the proportions of his figures for dramatic effect. The figures move energetically through deep space and changing light.

Tintoretto planned his compositions by placing wax or clay figures in a box—like actors on the stage of a theatre—and using candles for lighting effects. He studied these arrangements and drew sketches before beginning to paint. The theatrical character of Tintoretto's paintings can be seen in one of his most famous works, *Saint Mark Rescuing a Slave* (1548), which appears in the **Painting** article. The figures bend, gesture, and turn. Tintoretto achieved dramatic contrast by spotlighting some forms with intense colour and painting others in softer tones and shadows.

Tintoretto's real name was Jacopo Robusti. He was nicknamed *Il Tintoretto,* which means *the little dyer,* because his father was a dyer. Scholars believe Tintoretto taught himself to paint. He opened his first studio at the age of 21.

Tipi. See **Tepee.**

Tipperary is one of the six counties of the province of Munster in the Republic of Ireland. It is the largest of the inland counties. It is a mainly agricultural county. There are several market towns, the largest being Clonmel. Tipperary is well known because of the World War I song "It's a long way to Tipperary."

People and government. The population of Tipperary is only two-fifths of what it was in 1850. There was some growth during the 1970's, but emigration increased again in the 1980's. Three-fifths of the population live in rural areas.

About 96 per cent of the people of Tipperary are Roman Catholic. Those of other religions are mainly Church of Ireland, with a small number of Methodists.

Facts in brief about Tipperary

Population: *1991 census*—132,620.
Area: 4,254 km^2.
Largest towns: Clonmel, Thurles, Nenagh, Carrick-on-Suir, Tipperary, Roscrea, Cashel, Templemore, Cahir, Fethard.
Chief products: *Agriculture*—barley, cattle, horses, milk, pigs, sheep, sugar beet, wheat. *Other primary products*—barytes, building materials, peat, timber. *Manufacturing*—chemicals, clothing and textiles, electronic and other engineering goods, food and drink products, furniture and wood products.
Origin of name: From the Irish *Tiabraid Arann* (the well of Aral.

The Rock of Cashel had a fortress of the kings of Cashel and Munster by the A.D. 500's. It now has the remains of a group of medieval buildings. There is a beautiful Romanesque cathedral called Cormac's Chapel, a Gothic cathedral dating from the 1200's, and a massive castle built in the early 1400's. The name Cashel means *castle.*

Tipperary is the only Irish county with two separate county councils, those of Tipperary North and Tipperary South. Clonmel is the administrative centre for the south and Nenagh for the north.

The two *ridings* (administrative areas) are also separate parliamentary constituencies. North Tipperary elects three members and South Tipperary elects four to *Dáil Éireann* (the lower house of the Republic of Ireland's parliament). Clonmel has a borough corporation. There are urban district councils in Nenagh, Templemore, and Thurles in the north, and in Carrick-on-Suir, Cashel, and Tipperary town in the south. The training centre for the national police force *(Garda Síochána)* is at Templemore.

Economy. Half the workforce of Tipperary are employed in service industries, a quarter in agriculture and a fifth in manufacturing. Mining and public administration are more important in the north, and catering, manufacturing, and finance in the south. The leading service industry in the whole county is the retail trade.

The agricultural land in Tipperary is generally fertile, though it is of poorer quality in the upland districts. Farms are mainly of medium size, averaging 27 hectares.

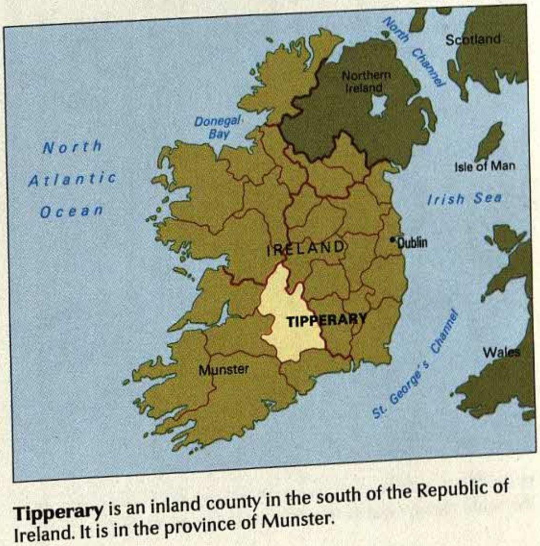
Agriculture is most specialized in the southwest, where dairying is the main farming activity. Elsewhere, many farmers rear and fatten beef cattle. Sheep are grazed in the uplands, and there is also some horse breeding. Pig production is the most important kind of farming in the south.

Arable crops cover one-sixth of the farmland, mostly in the extreme south and north. Feeding barley is the leading cereal crop, with malting barley being grown in the north and wheat in the south. Sugar beet and potatoes are the main root crops, and turnips are grown as sheep fodder in the north.

Food processing is of major importance in Tipperary's manufacturing industries. Meat, milk, and milling industries developed out of the county's farming activities. Modern engineering industries include the manufacture of electronic and electrical goods, and fabricated metal products. Clonmel is the largest manufacturing centre, with products that include cider, computers, dairy products, fibreboard, leather, meat, pharmaceuticals, printing, radiators, soft drinks, and textiles.

There is mechanized peat production and a peat briquette factory near Thurles. The main mineral products are coal (from Ballingarry) and *barytes,* a mineral formed from barium sulphate (from Silvermines). Foresters grow conifers in upland areas.

The major roads and the railways in Tipperary are those linking Dublin with Cork and Limerick, and Limerick with Waterford. The national primary roads are the N7 through Nenagh to Limerick, the N6 through Cashel to Cork and the N24 through Tipperary and Carrick-on-Suir. Limerick Junction, which is near Tipperary town, is Ireland's second most important railway junction after



Tipperary is an inland county in the south of the Republic of Ireland. It is in the province of Munster.

Dublin. The lines are to Dublin, Cork, Limerick, and Waterford. A branch railway from Limerick to Ballybrophy serves Nenagh and Roscrea.

Land. Tipperary has borders with Laois and Kilkenny to the east, Waterford and Cork to the south, Limerick and Clare to the west, Galway and Offaly to the north. The greatest distances are 105 kilometres from north to south and 70 kilometres from east to west.

Tipperary consists of a lowland, above which rise separate upland areas. The lowland is mainly limestone covered by Ice Age material and some peat bogs. The River Suir drains much of the land southwards. Northern and western parts of the county drain towards the River Shannon and Lough Derg, which forms the northwestern boundary. These waters are used for pleasure boating.

The upland areas are sandstone shale and slate. In the south are the Galtee Mountains (which rise to 920 metres), the Knockmealdown Mountains and Slievenamon. In the east are the Slieveardagh Hills. In the west is the extensive Silvermine Mountain system. This extends northeastward to Devilsbit Mountain and the Arra Mountains overlooking Lough Derg.

The annual rainfall is 100 centimetres on the lowland but higher on the uplands. Average temperatures are 5° C in January and 16° C in July.

History. There is a long history of human settlement in Tipperary. In 1980, people discovered the Derrynaflan hoard, a unique collection of ancient Irish altar vessels, on an island in a bog. There are also many castles and ecclesiastical remains in the county.

West Gate, in O'Connell Street, Clonmel, was built in 1831 on the same narrow site as the medieval town gate.

Clonmel lies in the valley of the River Suir in County Tipperary. It is the birthplace of the writer Laurence Sterne.

Tipperary was in the old Gaelic territories of Ormond and Thomond. The O'Briens and O'Kennedys were major Irish families. After the Anglo-Norman invasion in the 1100's, the de Burgo or Butler family, later earls of Ormond, dominated the region. Cashel was for a time the seat of the kings of Munster, and later became the ecclesiastical capital of the province. The impressive Rock of Cashel, with its medieval church ruins, is one of the most popular historical sites in Ireland. Another important site is the Butler castle in Cahir. Holy Cross Abbey, near Thurles, was a Cistercian medieval monastery. Most of the larger towns of the county date from medieval times.

In the 1600's the British government granted lands in the county to settlers. The Great Famine of the 1840's resulted in the death or emigration of one-fourth of the population. The Gaelic Athletic Association was founded in Thurles in 1884 and remains strong in the county.

Tippett, Sir Michael (1905-), is a British composer. He won fame with his oratorio *A Child of Our Time* (1944)—the story of a boy caught up in the toils of war—and his operas *The Midsummer Marriage* (1952), *King Priam* (1961), *The Knot Garden* (1970), and *The Ice Break* (1977). His other works include symphonies, a concerto for double string orchestra, piano sonatas, and string quartets. He spent 20 years in adult education in music.

Tippett was born in London and studied at the Royal College of Music. He refused to fight during World War II (1939-1945), because of his pacifist beliefs. He was knighted in 1966.

Tipu Sultan (1750-1799), also known as *Tipu Sahib,* was ruler of the southern Indian state of Mysore from 1782 to 1799. He became known as the *Tiger of Mysore* because of his opposition to British rule.

Tipu Sultan was born in Devanhalli, Mysore, in what is now the Indian state of Karnataka. At the age of 15 Tipu joined his father, Hyder Ali, on the battlefield. Together they fought the British in the First Mysore War (1767-1769). In 1780, the British were badly beaten. Tipu Sultan continued the struggle against the British and their allies, the Marathas and the Nizam of Hyderabad.

In 1789, Tipu made the mistake of allying himself with France, hoping for French military aid. The following year, Tipu invaded the neighbouring state of Travancore, which was under British protection. In 1792, he was defeated by General Charles Cornwallis and forced to give up half his territory.

In 1799, Colonel Arthur Wellesley with 16,000 men, General Harris with 21,000 men, and 6,000 men from Bombay, marched to Tipu's capital Srirangapatnam. In May, the British forces broke through the city wall. Tipu rushed to the spot. He was shot and killed.

Tiranë (pop. 260,000) is the capital and largest city of Albania. Tiranë, also spelled *Tirana,* lies on a coastal plain about 32 kilometres east of the Adriatic Sea. For location, see **Albania** (map).

Tiranë's central district has wide avenues lined by attractive stone buildings. The city is Albania's educational and cultural centre. The State University and several research institutes, museums, and theatres are there. Tiranë is the home of Albania's major publishing and broadcasting companies and of several light industries.

The Ottoman commander Barkinzadeh Suleiman Pasha founded Tiranë in the early 1600's. Tiranë became the capital of Albania in 1920. In the early 1920's, only about 12,000 people lived in the city. In the mid-1900's, the Albanian government expanded Tiranë's boundaries. Since then, many Albanians have moved to the city to work in industries and the government.

Tiros. See **Space exploration** (Artificial satellites).

Tirso de Molina was the pen name of Gabriel Téllez (1584-1648), a Spanish playwright. His masterpiece *The Deceiver of Seville* (1630) introduced the legend of Don Juan in literature (see **Don Juan**). Tirso probably wrote nearly 400 plays, of which 86 survive. They include historical and religious dramas, light comedies about palace society, and romantic tragedies. Tirso had a good understanding of psychology and showed greater skill in creating characters than any other Spanish playwright of his time. He also wrote light-hearted tales, *The Gardens of Toledo* (1624); and the more serious *Pleasure with Profit* (1635), a collection of stories, short plays, and verse. Tirso was born in Madrid. He was a friar and an important official in the Order of Mercy.

Tishah be-av is a Jewish day of mourning observed on the ninth day of the Hebrew month of Av (approximately August). On that day, Jews commemorate the destruction of the First Temple in Jerusalem in 587 or 586 B.C. and the destruction of the Second Temple in A.D. 70. The day also commemorates other tragic events in Jewish history, including Nazi Germany's campaign of mass murder of Jews called the Holocaust. For three weeks before Tishah be-av, Jews observe partial mourning and hold no weddings or celebrations. Many Jews fast throughout the day. The Biblical Book of Lamentations is recited in the synagogue on the evening that begins the holiday. During the morning service, a collection of poems is added that mourn the destruction of the temples and other tragic occasions.

Tisiphone. See **Furies.**

Tisquantum. See **Squanto.**

Tissue is a group of similar cells that work together to perform a particular function in an organism. Groups of tissues, in turn, form the organs of animals and plants.

Animal tissues are generally divided into four groups: (1) connective tissue, (2) epithelium, (3) muscle, and (4) nervous tissue.

Connective tissue is composed of cells and an abundant *intercellular material.* In most connective tissue, the intercellular material consists of fibres and a transparent, jellylike *ground substance.* Some connective tissues surround and connect other tissues and organs. For example, bone and cartilage are connective tissues that support and protect the body. Blood and lymph are connective tissues in which the intercellular material is a fluid.

Epithelium consists of tightly packed cells. The two main types of epithelium are membranes and glands. Epithelial membranes form the outer layer of the skin. They also line such internal body surfaces as those of the digestive tract and of the blood vessels. Glands produce secretions, such as hormones and perspiration.

Muscle consists of cells that alternately contract and relax. These actions allow the muscles to move parts of the body and to move substances through the body.

Nervous tissue consists of highly specialized cells that conduct nerve impulses throughout. Nervous tissue enables the body to coordinate many of its functions and to respond to a wide variety of stimuli.

Plant tissues. Plants have two major types of tissues, *meristematic* and *permanent.* Meristematic tissues consist of immature cells that divide continuously. The growing tips of roots and shoots are composed of meristematic tissue. Permanent tissues consist of mature cells that have special functions. Types of permanent tissues include *epidermis, parenchyma, xylem,* and *phloem.* Epidermis forms a plant's protective outer covering. Parenchyma stores food. Xylem conducts water from the roots to other parts of a plant. Phloem carries food throughout the plant.

Related articles in ***World Book*** include:

Connective tissue
Epithelium
Histology
Life (diagram: Structural units)
Membrane
Muscle
Nervous system

Tissue transplant is any tissue or organ permanently transferred from one part of the body to another, or from one person to another. Transplanted tissues and organs replace diseased, damaged, or destroyed body parts. They can help restore the health of a person who might otherwise have died or have been disabled.

Types of transplants. Transplants of tissues from one part of the body to another are called *autografts.* They have a high success rate because the body does not recognize the transferred tissue as foreign. Skin, bone, and hair tissues are frequently autografted. For example, surgeons routinely use skin autografts to repair damage from severe burns (see **Skin grafting**).

Transplants from one person to another are called *allografts.* In many cases, the recipient's body rejects an allograft. Rejection occurs because the immune system, the body's chief defence against diseases, recognizes the cells of the transplanted tissue as foreign. White blood cells called *T cells* then attack the transplant. If this process is not controlled, the transplant eventually will fail. Rejection poses a major problem in the transplantation of tissues and organs that consist mainly of living cells—such as the heart, kidneys, lungs, liver, and bone marrow. But some tissues—including cartilage, hard layers of the bones, and the cornea of the eyes—can be allografted easily. These tissues contain relatively few living cells, and so are less likely to be recognized as foreign by the recipient's immune system.

Matching tissues. To help overcome rejection of transplanted tissue, researchers have developed methods for matching donor and recipient tissues. These methods include identifying certain proteins—called *HLA antigens*—on the surface of the cells. Scientists have identified a number of HLA antigens. Each person inherits eight HLA antigens—four on one chromosome inherited from the father, and four on one chromosome from the mother. The greater the number of HLA antigens in common between the donor and recipient, the better the chances are for a successful transplant.

About 1 in 4 pairs of *siblings* (brothers and sisters) have exactly the same HLA antigens, because they have inherited the same pair of chromosomes. Transplants between HLA-identical siblings have the best chance of success. Kidney transplants often involve HLA-identical siblings. They are possible because both the donor and the recipient are able to function with one kidney.

Combating rejection. Many transplant candidates have no HLA-identical siblings. Furthermore, such organs as the heart and liver can only be obtained from a deceased donor because their removal would kill a living donor. The chances of an exact HLA match between a transplant candidate and an unrelated deceased donor are poor. In these cases, doctors match the donor and recipient tissues as closely as possible, and then administer drugs to limit the immune system's reaction. In so doing, however, they weaken the body's chief means of fighting infections. During the 1980's, doctors began using *cyclosporine* to combat rejection. This drug interferes less than other antirejection drugs with the immune system's ability to fight infections. Researchers have also developed drugs which act against the T cells that cause rejection. One of these drugs is a type of *monoclonal antibody* (see **Monoclonal antibody**).

See also **Bone bank; Cyclosporine; Immune system; Lymphatic system** (Rejection of transplanted tissue).

Tit is the name of over 50 species of small songbirds. Many have pale or white cheeks that contrast with black or dark head markings that look like a cap. Some species have crests. The bill is short and sturdy. Tits are agile, acrobatic birds that will hang upside down in search of food.

Tits are forest and woodland birds that also live in parks and gardens. In Europe, the *crested tit* and the *coal tit* live mainly in *coniferous* (needleleaf) forests. The *willow tit* prefers damp woodland with decaying trees. The *blue tit* feeds mainly on insects in the tops of broadleaf trees, but it is also a common garden visitor. The *great tit* also visits gardens, but lives mainly in broadleaf woodlands and thickets. This species has a rich variety of call notes and song. Most notes have a ringing, metallic sound. Both blue tits and great tits have learned to steal cream from bottles of milk left on doorsteps.

These tits build their nests in holes in trees. Some, such as the great tit, use existing nest holes. Others, such as the willow tit and crested tit, hollow out their own nests in soft, rotting wood. In winter, tits of the Northern Hemisphere forage for food in mixed parties made up of different species.

The blue tit, *above,* is a common bird of European woodlands. It also feeds and nests in parks and gardens.

The largest tit is the *sultan tit* of Southeast Asia, which is about 20 centimetres long. It is a glossy, blue-black colour with a bright yellow crown and belly. The *black tit* of Africa is another large species.

There are several species of long-tailed tits that build elaborate purselike nests. The nests are constructed of moss and lichens, lined with feathers, and bound together with cobwebs. *Penduline tits* are named after their hanging nests made from grasses, hair, and fluff from the leaves and seeds of willow trees.

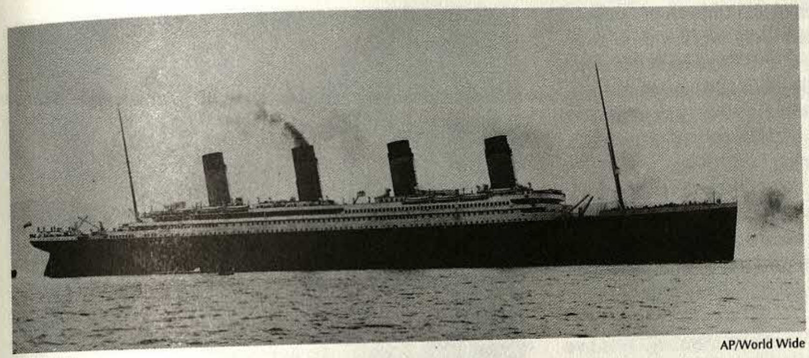
Scientific classification. True tits belong to the family Paridae. The crested tit is *Parus cristatus;* the coal tit is *P. ater;* the willow tit is *P. montanus;* the blue tit is *P. caeruleus;* the great tit is *P. major;* the sultan tit is *Melanochlora sultanea;* and the black tit is *Parus leucomelas.* Long-tailed tits belong to the family Aegithalidae, and penduline tits belong to the family Remizidae.

Titanic was a British passenger ship that struck an iceberg and sank in the North Atlantic Ocean in 1912. The disaster occurred on the liner's first voyage, from Southampton, England, to New York City. The *Titanic* sideswiped the iceberg at about 11:40 p.m. on April 14. The impact caused a number of small cracks and failed riveted seams in the ship's hull. Seawater flooded through the bow of the ship. About $2\frac{1}{2}$ hours later, the vessel broke in two and sank.

The *Titanic* carried enough lifeboats for only about half of its approximately 2,200 passengers and crew. The first rescue ship to reach the site, the British liner *Carpathia,* arrived about 4:00 a.m. and picked up 705 survivors, most of whom were women and children. A total of 1,517 people died in the disaster. The *Titanic's* captain, Edward J. Smith, went down with his ship.

The *Titanic* was the largest and most luxurious ocean liner of its time. It *displaced* (moved out of place) more than 53,000 metric tons of water and measured 269 metres in length. Many people believed the ship was unsinkable because its hull was divided into 16 watertight compartments. Even if 2 of those compartments flooded, the ship could still float. As a result of the collision with the iceberg, 6 compartments initially flooded.

In 1985, a team of French and American scientists led by Robert D. Ballard of the United States and Jean-Louis Michel of France found the wreckage of the *Titanic.* The ship lay in two sections about 650 kilometres southeast of Newfoundland at a depth of about 3,800 metres.



The "unsinkable" *Titanic* was believed to be the safest ship afloat. But in 1912, while crossing the Atlantic on its first voyage, the *Titanic* sank after striking an iceberg. About 1,500 people died in the disaster, and some 700 survived.

AP/World Wide

For years, people thought that the *Titanic* sank because the iceberg cut a huge gash in its hull. But the wreck showed no sign of a gash. A study of steel samples from the ship concluded that the hull was made of a steel that became brittle in the frigid North Atlantic waters and fractured easily during the collision. Inquiries have also shown that the *Titanic* was travelling too fast for an area where there was danger of icebergs.

Titaniferous ore is an iron ore rich in the metal titanium. It is usually a black, granular mixture of the minerals ilmenite and magnetite. See also **Ilmenite; Titanium.**

Titanium is a chemical element with symbol Ti. It is a lightweight, silver-grey metal. Its atomic number is 22, and its atomic weight is 47.88. The density of titanium lies between that of aluminium and stainless steel. It melts at 1667 °C (±10 °C) and boils at 3287 °C.

Titanium resists seawater and sea-air corrosion or rust as well as platinum and better than stainless steel. Many highly corrosive acids and alkalies do not affect titanium. It is a *ductile* metal—that is, it can be drawn into wire. It also has a higher strength-weight ratio than steel. All these qualities make it a metal of great importance.

Uses. The first commercial use of titanium was as an oxide to substitute for white lead in paint. Titanium dioxide is also used in the manufacture of floor coverings, paper, plastics, porcelain enamels, rubber, and welding rods. Barium titanate, a compound of barium and titanium, can be used in place of crystals in television and radar sets, and microphones. The gem *titania* is made from crystals of titanium oxide. When cut and polished, titania is more brilliant than the diamond, though not as hard. Titanium tetrachloride, or titanium combined with chlorine, has been used for smoke screens, and is the starting point for making the metal.

Titanium metal serves as an important alloying element. The armed forces use large amounts of titanium in aircraft and jet engines, because it is strong but light. It also withstands operating temperatures up to about 427 °C, which makes it useful for machinery.

Location of deposits. Titanium ranks as the ninth most plentiful element. But the difficulty of processing the metal makes it expensive. Titanium is never found in a pure state. It usually occurs in ilmenite or rutile. But it may be found in titaniferous magnetite, titanite, and iron (see **Ilmenite; Rutile; Titaniferous ore**).

The leading titanium-producing countries include Australia, Canada, China, India, Malaysia, Norway, and South Africa. Russia and Ukraine also have significant titanium deposits.

Discovery and manufacture. Titanium was discovered by William Gregor of England in 1791, and named by Martin Klaproth of Germany in 1795. It was not until the 1930's, however, that a refining method adaptable to large-scale production was worked out by William Kroll of Luxembourg. The Du Pont Company first produced the metal commercially in 1948. At the present time, production remains low because of the difficulty and expense of separating titanium from the ores with which it is found. The United States manufactures most of the refined metal. Japan and the United Kingdom also manufacture titanium.

Titans were the first gods in Greek mythology. Most of them represented, in human form, such natural phenomena as the earth, sky, and sun. Previously, the universe had existed in a state of emptiness called *Chaos.*

The first Titan was Gaea, the earth. She emerged from Chaos and gave birth to Uranus, the sky. She then married him. Gaea and Uranus had many offspring. The youngest and most important was Cronus, who married Rhea, his sister. Cronus deposed Uranus and became the king of the gods.

Rhea bore Cronus many children, but he swallowed them as soon as they were born to prevent one of them from overthrowing him. Rhea was determined to save Zeus, her youngest son. She tricked Cronus into swallowing a stone wrapped in baby clothes instead. Then she hid Zeus on the island of Crete.

After Zeus grew up, he tricked his father into vomiting up all the offspring. Zeus then led his brothers and sisters in a war against Cronus and overthrew him. Zeus banished Cronus and the Titans who had supported him to Tartarus, an underground region. The defeat of Cronus established Zeus as the supreme ruler of the universe and thus played an important role in the religion of the ancient Greeks.

See also **Mythology** (Greek mythology); **Atlas; Cronus; Prometheus; Tartarus; Uranus; Zeus.**

Tithe. The word *tithe* comes from the Anglo-Saxon word *teotha,* which means a *tenth part.* The term usually means a tax of one-tenth laid on the profits of a piece of land. In the Bible, the tithe was primarily for the support of the priesthood (Num. 18: 20-32). There was also tithing for the poor.

In the 500's, councils of the Catholic Church began to ordain the payment of taxes. In Charlemagne's time, such payment became state law. In England, tithes were demanded by Pope Adrian I from all lands except those belonging to the Church and the Crown. A *tithe rent* is still charged in a few parishes of the Church of England. In Quebec, Canada, the Roman Catholic Church is supported by tithes. Members of some Protestant churches also contribute a tenth of their income to the church.

Tithe barns are barns built in England during the Middle Ages to store the large quantities of grain that were paid to the church as *tithes.* A tithe was a *tenth* part of the produce of a farm. Most tithe barns were big, some being almost 60 metres long. In 1836, Parliament changed the payment of tithes from produce to cash, and many tithe barns were abandoned or sold to private landowners. Tithe barns still stand in many parts of England.

Titi is a type of small South American monkey. Titis live in the tropical rainforests of the Amazon, in the Orinoco River Basin, and in eastern Brazil. Male and female titis are about the same size. They measure about 30 to 40 centimetres long, and have 35 to 50 centimetre long tails. They weigh about 1 kilogram and have grey, reddish-brown, or black fur. Titis live in trees and occasionally come to the ground. They feed mainly on fruit but also eat many types of leaves and insects.

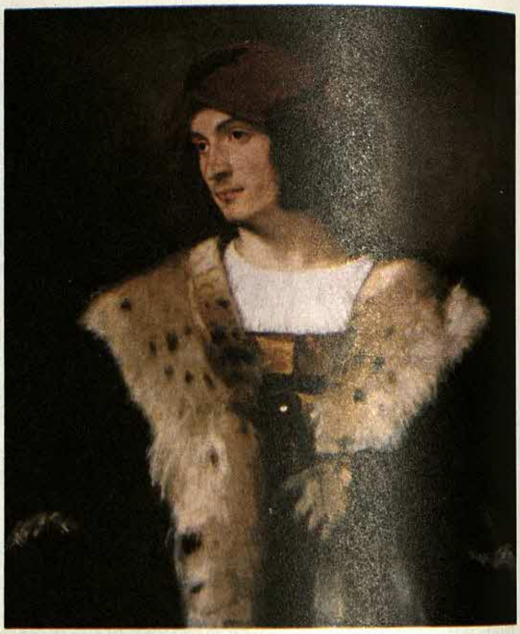
Titis live in family groups that consist of an adult male and female pair and their offspring. A family group uses many different calls to defend its territory against other titi groups. Titis have one breeding season each year, and the female produces only one infant. Both parents care for the newborn. At 2 to 3 years of age, a titi leaves its parents to start its own family.

Titi monkeys often demonstrate a curious social behaviour called *tail-twining.* Two, three, or four titis sit on a branch and wrap their tails in a spiral. Titis exhibit this behaviour while resting or sleeping.

People hunt many types of South American monkeys for food. However, hunters usually do not kill titi monkeys because of their small size. The greatest enemies of titis are hawks and other predatory birds.

Scientific classification. Titis belong to the New World monkey family, Cebidae. They are genus *Callicebus.*

The titi is a small South American monkey. The animal lives in trees in tropical rainforests. The titi feeds mainly on fruit but also eats many kinds of leaves and insects.



Titian's *Man in a Red Cap* reflects the subject's personality through his pose and expression. Titian probably completed the portrait in 1516, at the beginning of his mature period.

Titian (1487?-1576) was a Venetian painter of the Italian Renaissance. During his long career, which lasted about 70 years, he became one of the most influential and successful painters in the history of art.

Titian's works include portraits and paintings of myths and religious scenes. He developed a style that strongly influenced European painting for more than 200 years. Titian used bright colours, applied his paint in bold brushstrokes, and made one colour seem to blend into another. His style is shown in *The Rape of Europa* (1562), which appears in the **Painting** article. This style of painting influenced many great artists, including El Greco, Rembrandt, and Peter Paul Rubens.

Titian painted portraits of royalty and aristocrats. He portrayed his subjects as elegant but spirited. Titian skilfully showed the human side of his subjects through facial expressions and gestures. The works of many great portrait painters, including Sir Anthony Van Dyck and Diego Velázquez, show his influence.

Titian was born in Pieve di Cadore, near Venice, Italy. His real name was Tiziano Vecellio. Titian moved to Venice as a boy to study painting under Venetian masters. At that time, Venice was an important centre of Italian art. He was apprenticed to two artists, Gentile Bellini and then to his brother Giovanni Bellini. Titian's early works show the influence of Giovanni Bellini and of his artist friend Giorgione.

About 1515, Titian began to produce masterpieces. Titian's success led most of Europe's leading art patrons to buy and pose for his paintings. Titian's clients included Holy Roman emperors Charles V and Ferdinand I, Pope Paul III, King Francis I of France, King Philip II of Spain, and many of the most important Italian nobles.

See also **Drawing** (picture: A pen-and-ink drawing); **Painting** (Venetian painting).

Titicaca, Lake. See **Lake Titicaca.**

Title is a legal term often used to describe ownership of property. The term began with transfers of land. A history of the ownership of land is called a *chain of title.*

The term *title* can be used to describe the way an owner obtains lawful possession of property. In addition, it often refers to a legal document that describes the interest of the owner. Such documents include deeds to real property, a title to a car, the patent for an invention, or the copyright held by an author.

A title to property may be acquired in many ways. If a person buys property from another person, or receives it as a gift or through a will, the title is *derivative.* A title is *original* if the property is not obtained from someone else. For example, trappers may capture wild animals and make them their property. Title by *adverse possession* is a title acquired against the consent of the owner. It is obtained by wrongful entry and continuous possession for a time fixed by law—12 years in many countries. Suppose, for example, that Jones farms Smith's land for over 12 years against Smith's consent, but Smith does not take legal action against Jones for using the land. Jones then has an original title by adverse possession.

See also **Deed; Estate; Torrens system.**

Tito, Josip Broz (1892-1980), established a Communist government in Yugoslavia after World War II (1939-1945) and then became the country's ruler. In 1948, he declared Yugoslavia's independence from Soviet control. This act set an example that China and some Eastern European Communist nations later followed. Tito was the first Communist leader to permit his people some economic and social freedom.

Early life. Tito was born Josip Broz, the son of a peasant family, in Kumrovec, Croatia. At that time, Croatia was part of Austria-Hungary, but it later became part of Yugoslavia. Broz became a metalworker. He was conscripted into the Austro-Hungarian Army in 1913. In 1915, in World War I, he was wounded and captured by Russian troops. In 1917, the Communists released him from prison after they had taken power in Russia. It was then that he joined the Communist Party.

In 1920, Broz returned to his homeland, which had gained independence after World War I ended in 1918. He helped organize the Yugoslav Communist Party, but it was outlawed and Broz was sent to jail in 1928. He used the name *Tito* to confuse the police after his release in 1934. He later added *Tito* to his real name. He was secretary general to the Yugoslav Communist Party from 1937 until 1966 when he became party president.

During World War II, Tito organized and led the *Partisans,* guerrillas who fought Germans occupying Yugoslavia. Another resistance group, the anti-Communist *Chetniks,* fought the Partisans, but lost. After the war, Tito had Chetnik leader, Draža Mihailovich, executed.

Yugoslav leader. Tito set up a Communist government in Yugoslavia in 1945, and it was recognized by the United States, Great Britain, and the Soviet Union. Tito became prime minister and defence minister. But Soviet efforts to control Yugoslavia led to a split between Tito and Soviet dictator Joseph Stalin. Stalin expelled Yugoslavia from the Soviet bloc in 1948. Tito became the first independent Communist leader. Later, he became a spokesman for nations that refused to take sides in the Cold War.

But Tito kept tight control over the Yugoslav people, and tolerated no opposition. He had his close associate, Milovan Djilas, jailed for criticizing the government. In 1963, Tito made himself president for life. Later, Tito released Djilas from jail, limited the power of the secret police, and encouraged some economic and political freedom.

In 1968, Tito supported Czechoslovakia's liberalization programme, and he criticized the Soviet Union for sending troops into the country to stop the reforms. In 1971, he became head of a presidential council formed to rule Yugoslavia. As chairman, Tito retained much of his power until his death.

See also **Yugoslavia** (History).

Titus was an early Christian who was a companion of Saint Paul. Titus was often mentioned in Paul's letters and served as Paul's special representative to the church in Corinth. According to tradition, Titus was the first bishop of Crete. His feast day is January 26.

The Epistle to Titus is a letter addressed to Titus that is the 17th book of the New Testament. The letter is traditionally attributed to Paul, but most modern scholars believe the letter was actually written by one of Paul's followers.

Titus (A.D. 41-81), a Roman emperor, was noted for his generosity and his regard for the people's welfare. He was born in Rome, the oldest son of Emperor Vespasian (see **Vespasian**). Titus served in civil and military posts in many parts of the empire. He captured Jerusalem in A.D. 70 after a long siege. Soon after, he was made coruler with his father, and succeeded him in 79. The tragic destruction of Pompeii and Herculaneum, when Mount Vesuvius erupted, occurred during the first year of his reign.

The *Arch of Titus* was begun by Vespasian as a triumphal arch for his son's victory at Jerusalem. It was finished in A.D. 81 and is located on the Sacred Way by the Forum of Rome.

Titus, Epistle to. See **Titus.**

Tivoli Gardens. See **Denmark** (Recreation; picture: Tivoli Gardens).

Tizard, Sir Henry Thomas (1885-1959), a British scientist, fostered the development of radar early in World War II (1939-1945). He also persuaded the Royal Air Force to learn the new tactics of air fighting that the introduction of radar made necessary. In 1934, Tizard was made chairman of the committee for the survey of air defence. In 1940, he led a scientific mission to Washington, which disclosed the British inventions. Tizard was born at Gillingham, in Kent, England.

TM. See **Transcendental meditation.**

TNT is short for trinitrotoluene, a powerful solid explosive. TNT is made up of the chemical elements nitrogen, hydrogen, carbon, and oxygen. The chemical formula for TNT is $CH_3C_6H_2(NO_2)_3$.

The explosive is made by nitrating the chemical compound toluene. The resulting explosive forms in pale yellow crystals that may darken to brown. These crystals of TNT can be handled safely and may even be melted at low heat without igniting. TNT is used alone and in mixtures with other explosives, such as PETN, RDX, and ammonium nitrate. It is chiefly used as the explosive charge for shells and bombs.

See also **Explosive.**

Toad is a small, tailless animal that closely resembles the frog. Toads and frogs both belong to a class of animals called *amphibians* and live part of their life in water and part on land. But toads have broader bodies, drier skin, and shorter, less powerful back legs than do most frogs.

Many toads are dull brown or grey. But some have vivid colouring, such as green stripes or red spots. The skin of most toads is dry, rough, and covered with warts. Despite superstition, a person cannot get warts by touching a toad. But a pair of large *parotoid glands* on top of a toad's head give off a poison that can irritate the eyes or cause illness. The poison also has an unpleasant taste that helps protect the toad from enemies.

A toad uses its long, sticky tongue to prey on insects and other small animals. It can flip out its tongue, seize an animal, and swallow it—all in an instant.

Toads and frogs make up a scientific order known as Anura or Salientia. Members of several families in this order are commonly called toads. But zoologists use the term *true toads* to describe only members of the family Bufonidae, such as the *common toad.*

The life of a toad. Most toads develop from eggs laid in water and spend their adult life on land. Some, such as the *fire-bellied toad* and the *smooth-clawed toad,* spend their adult lives in water. All toads return to water to breed. Temporary pools resulting from spring or summer rain are typical breeding sites. In most toads, the male attracts the female with a mating call.

Almost all female toads lay eggs. Some females lay more than 30,000 eggs at a time. As the female deposits eggs in the water, the male clings to her body and fertilizes them. Toad eggs look like tiny, black spots enclosed in long strings of clear jelly. The jellylike substance helps protect the eggs.

Within a few days, small tadpoles hatch from the eggs. The tadpoles remain in the water as they go through a process called *metamorphosis.* In this process, the tadpoles gradually develop the characteristics of the adult toad. In most toads, metamorphosis takes from three to eight weeks. The young toads then leave the water and begin their life on land. Young toads grow rapidly. Some reach adult size in a year or less.

The striped toad of South America, like most species of toads, has dry, warty skin. Glands in a toad's skin contain a poisonous liquid that the animal releases if attacked.

Toads avoid direct sunlight and heat. They are most active at night or on rainy days. During hot, dry spells, toads dig deep into the ground and remain there. This behaviour is called *aestivation.* Toads that live in areas with harsh winters hibernate during the cold weather.

Scientists do not know how long toads live in the wild. Toads in captivity have lived more than 10 years.

Kinds of toads. There are more than 300 species of true toads living mainly on the ground. Compared to frogs, they are more tolerant of dry conditions. Toads are found in every part of the world except Antarctica, Australia, and New Zealand. In Europe, the common toad is often found in gardens, where it eats pests such as slugs. Another species, the *natterjack toad,* is distinguished by a yellow line along its back, and a very noisy call during the mating season. It lives on sandy heaths and in damp dune *slacks* (damp, boggy areas behind and between sand dunes).

The *cane toad,* also called the *giant toad* or *marine toad,* is one of the largest toads. It grows to more than 23 centimetres long. Although native to the southern United States and Central America, it was introduced into Queensland, Australia, in 1935, where it became a pest. See **Cane toad.**

Other families of toads include the *spadefoot toads.* They have a sharp edge on their hind feet, which they use to dig burrows. The *midwife toad* has an unusual method of reproduction. The male carries fertilized eggs on his back for two to three weeks until they are ready to hatch.

Some toads, such as the *clawed* and *Surinam toads* have no tongue. They live mainly in water, and are found in tropical South America and Africa. The smooth-clawed toad eats only green algae. The *Mexican*

Cane toads were imported into Queensland, Australia, to help control beetles that were pests in the sugar cane fields. The toads have become pests themselves.

burrowing toad lives in a burrow in the ground, which it leaves only at night to hunt for termites. The *African clawed-toad* digs for prey in mud. It can conceal itself by changing colour from grey to black. The *African live-bearing* toads are the only toads that do not lay eggs. Its females give birth to live young.

Scientific classification. True toads make up the toad family, Bufonidae. The common toad is *Bufo bufo,* the natterjack toad is *B. calamita,* the cane toad is *B. marinus,* and the fire-bellied toad is *Bombina orientalis.* Spadefoot toads belong to the family Pelobatidae. The midwife toad belongs to the family Discoglossidae. It is *Alytes obstetricans.* Clawed and Surinam toads belong to the family Pipidae. The Mexican burrowing toad is the only member of the family Rhinophrynidae. It is *Rhinophrynus dorsalis.* The African clawed toad is *Xenopus laevis.* African live-bearing toads belong to the genus *Nectophrynoides.*

See also **Amphibian; Midwife toad; Surinam toad; Tadpole.**

Toadfish is the name of a group of large-headed fish that live in tropical seas. There are about 65 species of toadfish. Most measure less than about 45 centimetres long. Some species can produce light called *bioluminescence* (see **Bioluminescence**). Most toadfish make grunting noises. Some species have poisonous spikes.

The toadfish lives on the bottom of the sea.

Female toadfish commonly make nests for their eggs. The males guard the nest and can be extremely aggressive if the eggs are threatened. Certain species of toadfish are popular aquarium pets.

Scientific classification. Toadfish make up the toadfish family, Batrachoididae.

Toadflax is a plant with yellow flowers and pale green leaves. It is native to the United Kingdom and Europe, and has been introduced into North America. Toadflax grows in fields and on waste ground. It reaches a height of about 60 centimetres. The flowers cluster along the upper part of the stem. They are tube-shaped, with the edge cut into an upper and lower lip. The upper lip has two lobes, the lower lip has three. A thick, orange-coloured ridge on the middle lobe covers the mouth of the tube. The weight of a bee looking for nectar forces the mouth of the tube open. Toadflax is sometimes grown in gardens, and has been used to treat digestive ailments.

Scientific classification. Toadflax is in the figwort family, Scrophulariaceae. It is *Linaria vulgaris.*

Toadstool. See **Mushroom.**

Tobacco is a plant whose leaves are used chiefly in making cigarettes and cigars. Other tobacco products include smoking tobacco for pipes, chewing tobacco, and snuff. Inferior grades of tobacco leaves are used in making insecticides and disinfectants. The stalks and stems serve as an ingredient for some types of fertilizer.

Tobacco ranks as an important crop in more than 60 countries. During the early 1990's, the annual worldwide production of tobacco totalled about 7 million metric tons. China leads in tobacco production, followed by the United States, Brazil, and India.

The amounts of tobacco grown in Cuba and Jamaica are relatively small, 40,000 metric tons and 2,000 metric tons, respectively. But the cigars made from these tobacco leaves are of very high quality.

The taxes on tobacco products provide a major source of revenue for many governments. Taxes on tobacco can total many times the amount that the growers receive for their crops.

Tobacco contains small amounts of nicotine, a substance that acts as a stimulant on the heart and other organs. Nicotine also stimulates the nervous system, causing people to become addicted to it. Doctors believe these stimulating effects of nicotine help make smoking pleasurable. However, concentrated amounts of nicotine are poisonous. The nicotine consumed from cigarettes may contribute to the occurrence of heart attacks and stomach ulcers. Other substances in the smoke may cause lung cancer. See **Smoking; Drug abuse.**

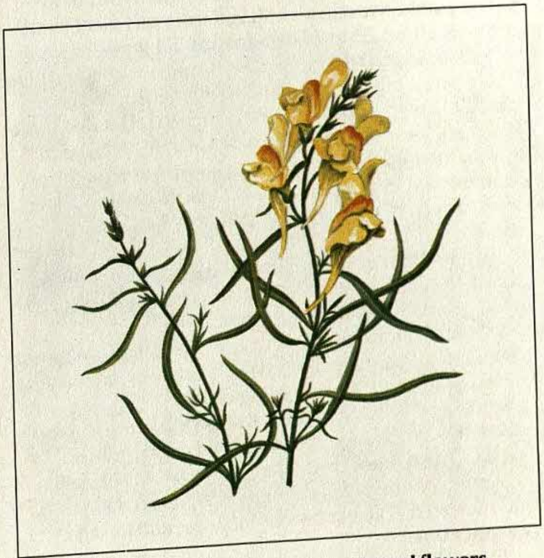
The tobacco plant

Tobacco is related to such plants as the tomato and the potato. It first grew in the Caribbean countries and in Mexico and South America.

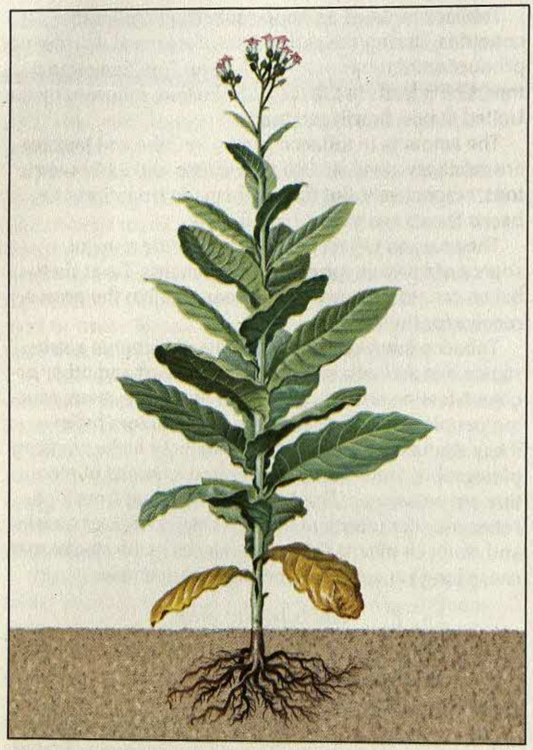
Cultivated tobacco is an *annual* plant—that is, it lives only one growing season. The plant reaches a height of about 1.2 to 1.8 metres. It produces about 20 leaves, which measure from about 60 to 75 centimetres long and 35 to 45 centimetres wide. The tobacco plant ranges from light green to dark green in colour. A vigorous, mature plant can produce a million seeds yearly—enough to plant about 40 hectares of tobacco.

Kinds of tobacco

Cigarettes most commonly contain light-coloured (Virginia) or Oriental tobacco, or mixtures of these two



Toadflax has clusters of yellow, tube-shaped flowers.



The tobacco plant, *above,* lives for only one growing season. It stands from about 1.2 to 1.8 metres high and ranges in colour from light green to dark green. The plant has about 20 leaves and grows light pink flowers.

types. Oriental tobacco, used in Turkish cigarettes, has an aromatic flavour. It is grown in Turkey, Greece, Bulgaria, and the borders of the Black Sea. Latakia and Latakia-type tobacco is grown in Syria and Cyprus. It has a distinctive flavour and is used mainly in pipe smoking mixtures. It has smaller leaves than other types of tobacco plants. Most leaves picked from this plant measure only about 7.5 to 15 centimetres in length.

Tobacco is generally classified into four main groups: (1) air-cured tobacco, (2) fire-cured tobacco, (3) flue-cured tobacco, and (4) cigar leaf tobacco. The first three kinds are classified according to the method used in *curing* (drying) the leaves. More information on these methods appears in the *Curing tobacco* section. Cigar leaf tobacco is air cured, but it is classified according to its use.

Air-cured tobacco consists of two varieties, light air-cured and dark air-cured. Dark air-cured tobacco is used primarily for chewing tobacco and snuff.

Fire-cured tobacco has a distinctive smoky aroma and flavour. It is used to make smoking tobacco, chewing tobacco, snuff, and strong-tasting cigars.

Flue-cured tobacco is also called *bright tobacco* because the curing process turns it yellow to reddish-orange. Most flue-cured tobacco is used in cigarettes.

There are three types of cigar leaf tobacco: (1) cigar filler tobacco, (2) cigar binder tobacco, and (3) cigar wrapper tobacco.

Cigar filler tobacco is used in the body of cigars because it has a sweet flavour and burns evenly. Cigar binder tobacco was once used to hold filler tobacco together, but most cigar manufacturers now use *reconstituted tobacco sheets* instead. These sheets are made from coarse or damaged tobacco leaves. Today, cigar binder is used primarily in making chewing tobacco.

Cigar wrapper tobacco is used for the outside cover of cigars. It must have high-quality leaves that are smooth, thin, and uniform in colour. To grow leaves with these characteristics, farmers surround the tobacco with a framework covered by cloth. Producing this tobacco is difficult and expensive, and many manufacturers use reconstituted tobacco sheets to cover their cigars.

Raising and marketing tobacco

Planting and cultivation. The soil and climatic conditions that favour tobacco growth vary according to the kind of tobacco being raised. However, most tobacco grows best in a warm climate and in carefully drained and fertilized soil.

Tobacco seeds are planted in seed beds in late winter or early spring and covered with cloth or plastic. The plants grow 15 to 20 centimetres tall in 8 to 12 weeks and are then transplanted into the field.

Farmers cultivate the soil several times to keep it loose and to eliminate weeds and grasses. The last cultivation occurs after the plants reach a height of between about 45 and 60 centimetres.

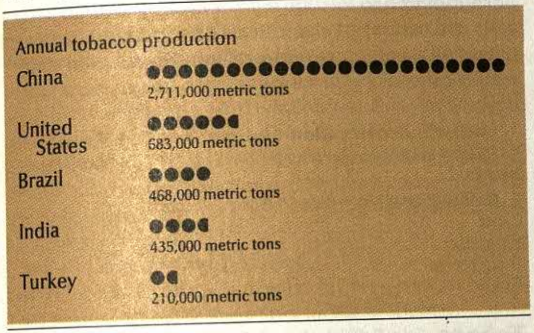
The upper part of the plant is *topped* (cut off) when it begins to produce flowers. This process allows the remaining leaves to become larger and heavier.

Harvesting tobacco. Farmers harvest tobacco from 70 to 90 days after it has been transplanted. They use two harvesting methods, *priming* and *stalk-cutting.*

Priming involves picking the individual tobacco leaves as they ripen. In many poorer countries the

Tobacco is *cured* in a special barn before being sent to market. In a modern curing barn, *above,* a furnace heats the air, which fans force through the drying leaves.

Leading tobacco-growing countries



Figures are for 1990.
Source: Food and Agriculture Organization of the United Nations.

leaves are still picked by hand, but most farmers in industrial countries now use priming machines. The priming method is used to harvest cigar wrapper, flue-cured, and some cigar filler tobaccos.

Stalk-cutting consists of cutting the entire plant with a hatchetlike tool. The stalks are then placed on sticks and left in the field for a day or two to wilt. Growers use the stalk-cutting method to harvest air-cured, fire-cured, and most cigar leaf tobaccos.

Diseases and pests. Diseases that attack tobacco include *black shank* and *black root rot.* Many farmers raise newly developed types of tobacco that resist black shank and various virus diseases. Crop rotation is the most effective way to control black root rot.

Budworms, flea beetles, grasshoppers, and other insects also damage tobacco plants. Farmers use insecticides to control these pests.

Curing tobacco involves drying the sap from newly harvested leaves. This process produces various chemical changes in tobacco that improve its flavour and aroma. There are three methods of curing tobacco: (1) air curing, (2) fire curing, and (3) flue curing. Each type of tobacco responds most favourably to one of these methods. Curing takes place in curing barns that are built specifically for the method used.

Air curing uses natural weather conditions to dry tobacco. Air-curing barns have ventilators that can be opened and closed to control the temperature and humidity. This process takes from four to eight weeks.

Fire curing dries tobacco with low-burning fires. The smoke gives fire-cured tobacco its distinctive taste and aroma. Farmers regulate the heat, humidity, and ventilation in the curing barns in order to avoid scalding the tobacco leaves. Fire curing requires from three days to six weeks.

Flue curing dries tobacco by heat from *flues* (pipes) connected to furnaces. The temperature is gradually raised from about 32° to 70° C until the leaves and stems are completely dry. The flue-curing method takes about a week.

Marketing tobacco. Farmers sell tobacco by two major methods, *loose leaf auctions* and *country sales.*

The term *loose leaf* refers to the practice of displaying and selling tobacco in leaf form rather than packed in containers.

Auction warehouses operate in cities and towns throughout tobacco-growing regions. Inspectors examine tobacco before it is sold and grade it according to government standards.

Buyers from tobacco companies bid on the tobacco, which is usually sold to the highest bidder. Some governments have *price supports* that guarantee the seller a certain price for tobacco. Government-sponsored organizations known as farmer *cooperatives* may buy the tobacco if no bidder offers this amount.

Country sales involve the direct sale of tobacco from farmer to buyer outside the auction system. Most cigar leaf tobacco is sold directly.

Manufacturing tobacco products

Freshly cured tobacco has a sharp aroma and bitter taste. Therefore, most tobacco is put into storage and allowed to age before being used in manufacturing tobacco products.

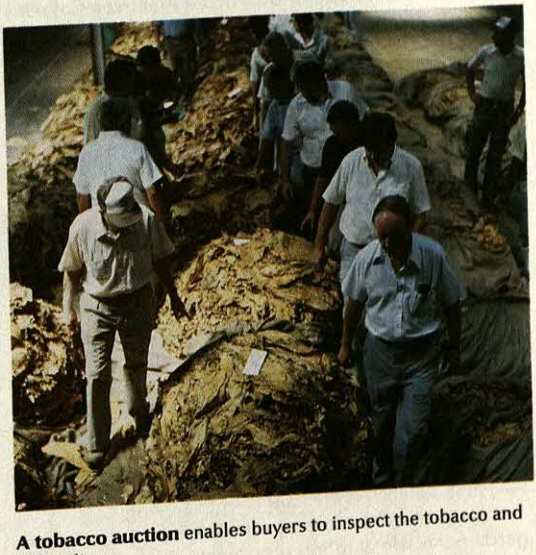
Prior to storage, most tobacco goes through a redrying process, during which it is completely dried and cooled. Manufacturers then restore some water throughout the leaves to ensure uniform moisture content. This practice prevents the leaves from breaking.

Next, the tobacco is stored for two or three years in barrellike containers. During storage, it ages and undergoes a chemical change called *fermentation.* Fermentation gives tobacco a sweeter, milder flavour and aroma and reduces its nicotine content. Smoking tobacco usually contains between one per cent and two per cent nicotine. Tobacco also loses moisture and becomes darker during aging.

A somewhat different procedure is used to age cigar leaf tobacco, which does not require redrying. Bales of this tobacco are placed in heated rooms or are simply hung up to ferment before storage.

Cigarettes account for the greatest proportion of tobacco consumed. The remainder is used in making cigars, smoking tobacco for pipes, chewing tobacco, and snuff.

Cigarette manufacturers may add such flavourings as honey, liquorice, menthol, and sugar to the blended to-



A tobacco auction enables buyers to inspect the tobacco and bid on it.

bacco. A chemical called *glycerine* is often added to preserve moisture.

Various machines handle the entire process of making and packaging cigarettes. Cigarette-making machines can produce about 4,000 cigarettes each minute.

Cigars consist of about 85 per cent cigar filler, 10 per cent cigar binder, and 5 per cent cigar wrapper tobaccos. Most cigars are made by machines, but the more expensive kinds are hand-rolled.

Most smoking tobacco is used in pipes, but some people smoke it in the form of cigarettes that they roll by hand. For flavour, manufacturers add tonka beans, vanilla leaves, and other substances. Tobacco flavourings are called *saucing compounds.*

Chewing tobacco is made from various types of inferior grade tobacco. Most chewing tobacco is treated with such saucing compounds as honey or liquorice.

Snuff consists of a coarsely ground mixture of tobacco leaves and stems that has been pressed into a fine powder. The powder is strained through cloth and flavoured with oils and spices.

History

American Indians smoked tobacco in pipes long before Christopher Columbus sailed to the New World in 1492. Columbus brought some tobacco seeds back to Europe, where farmers began to grow the plant for use as a medicine that helped people relax. In 1560, a French diplomat named Jean Nicot—from whom tobacco receives its botanical name, *Nicotiana*—introduced the use of tobacco in France. Spaniards and some other Europeans began to smoke hand-rolled cigarettes in the 1600's.

At first, the tobacco of the West Indies and the Orinoco Valley of South America were the only types known in Europe. Commercial production of tobacco began in North America in 1612, after an English colonist named John Rolfe took some tobacco seeds from South America to Virginia. The Virginia soil and climate were excellent for tobacco, and it became an important crop there and in other parts of the South.

Most of the tobacco grown in the American Colonies was exported to England until the American Revolution began in 1775. Manufacturers in the United States then began to produce smoking tobacco, chewing tobacco, and snuff for domestic use. Cigars were first manufactured in the United States in the early 1800's. Cigarette smoking became increasingly popular after the first practical cigarette-making machine was invented in the U.S.A. in the early 1880's.

The use of tobacco products has been a controversial issue for many years. During the 1500's, European doctors declared that tobacco should be used only for medicinal purposes. The Puritans in America considered it a dangerous narcotic. During the 1960's, scientists established that smoking tobacco products—especially cigarettes—could increase the risk of lung cancer, heart disease, and other illnesses.

Some cigarette manufacturers reacted to the medical findings by reducing the tar and nicotine content of cigarettes. However, doctors state that these measures have not eliminated the dangers of smoking.

Various laws have been passed in many countries regarding the sale of tobacco products. Since the 1960's, manufacturers in a growing number of countries have been required to include a health warning on all packages and cartons of cigarettes. Other laws ban radio and television commercials advertising cigarettes. In some countries smoking in various public places is prohibited.

Scientific classification. The tobacco plant belongs to the nightshade family, Solanaceae. The major kind is *Nicotiana tabacum.*

Related articles in ***World Book*** include:

Cigar
Cigarette
Drug abuse
Filter
Nicotine
Pipe
Snuff

Tobago. See Trinidad and Tobago.

Tobermory is a seaside resort on the north coast of the Island of Mull, in Strathclyde Region, Scotland. It is a fishing port. Tobermory has long been associated with a sunken Spanish galleon.

Tobey, Mark (1890-1976), was an American artist who painted elaborate linear abstract pictures, often on a small scale. Tobey's delicately coloured compositions have dense patterns of lines and small symbols. They have been compared to *calligraphy* (the art of fine handwriting). Tobey used the term *white writing* to describe his style. Tobey developed his calligraphic style after a trip to the Orient in the 1930's. Later he ordered his images into highly complex groupings of tiny forms. Tobey's paintings were admired by Europeans, who saw in them an American blend of Eastern and Western styles. Tobey was born in Centerville, Wisconsin, U.S.A.

Tobogganing is the winter sport of coasting on snow or ice by means of toboggans, which are sledges without runners. A toboggan is made of strips of hickory, ash, or maple, with the front ends curved back. The strips are fastened together by crosspieces into one unit. The under-surface is highly polished. The sledge is usually 1.8 to 2.5 metres long and about 45 centimetres wide. Four people make up a toboggan team. The one

Tobogganing is a popular winter sport. Participants coast down a snowy or icy hill on a sledge called a toboggan. A typical toboggan has no runners and its front end is curved back.

at the rear steers the sledge. Tobogganists have attained a speed of about 825 metres in 30 seconds, or more than 98 kilometres per hour.

Indian hunters first built toboggans to carry game over the snow. These were made of bark. The Eskimos used to make toboggans of whalebone. Bobsledding, an offshoot of tobogganing, has become a feature of the Winter Olympic Games. A bobsled can reach a speed of about 128 kilometres per hour. Both two-seat and four-seat bobsleds have a standard length of between 2.7 and 3.7 metres.

See also **Bobsledding; Sledge.**

Toc H is a Christian organization for men and women. It has more than 6,000 members in 500 branches throughout the world. It encourages Christian fellowship as well as practical voluntary work in the community.

Toc H began when Philip Clayton, a British army chaplain, opened a Christian soldiers club in Poperinhe, Belgium, in 1915 during World War I. He called it Talbot House in memory of Gilbert Talbot, a British soldier killed during the war. The name was shortened to T.H., which army signallers pronounced *Toc H.* After the war, in 1920, Clayton opened a new Talbot House in London. The association soon spread throughout the United Kingdom and to many English-speaking countries. In 1922, the League of Women Helpers of Toc H was formed. The original members were nurses who had used Talbot House. The men's and women's organizations were combined in 1971.

Tocopherol. See **Vitamin** (Vitamin E).

Tocqueville, Alexis de (1805-1859), was a French historian and political philosopher. He became famous for his book *Democracy in America* (1835-1840), a study of political and social institutions in the United States. His other classic work, *The Old Regime and the Revolution* (1856), describes how government policies and conflicts between the upper class and other classes caused the French Revolution (1789-1799).

Unlike many thinkers of his time, Tocqueville believed the spread of some form of democratic government was inevitable. In *Democracy in America,* he analysed what made free societies work and discussed the good and bad aspects of social equality. He warned that the "tyranny of the majority" would put great pressure on people to act like everyone else. As a result, democracy would tend to smother individuality and personal freedom. Tocqueville wrote the book after visiting the United States in 1831 and 1832.

Tocqueville was born in Paris into an aristocratic family. He served in the French legislature from 1839 to 1851 and briefly held the post of foreign minister in 1849. He died in Cannes.

Todd is a river in the Northern Territory, Australia. The riverbed is usually dry. It contains water only after heavy rainfall, which is extremely rare. A regatta known as *Henley-on-Todd* is held in September of each year. In this race, competitors carry bottomless boats up the dry bed of the river near Alice Springs in a parody of an ordinary boat race. The river's source region is in the Macdonnell Ranges, north of Alice Springs. It flows east, then southeast, for about 320 kilometres and disappears in the sands of the Simpson Desert, near the South Australian border. Just south of Alice Springs, it flows through the Heavitree Gap, which is also a route for the road, railway, and telegraph line.

The river was discovered in 1870 by the overland telegraph survey parties and was named after Charles Todd, a postmaster general and director of telegraphs for South Australia. Todd was mainly responsible for the construction of the Overland Telegraph.

Todd, Sir Charles (1826-1910), was postmaster general and government astronomer of South Australia. He supervised the construction of Australia's first overland telegraph. The original telegraphic link ran 2,900 kilometres between Port Augusta in South Australia and Port Darwin in the Northern Territory. When it was completed in 1872, it connected the Australian colonies with Asia and Europe by a submarine cable that linked Darwin and Java. See **Overland Telegraph.**

Todd was born at Islington, in London. In 1841, he joined the Royal Observatory at Greenwich. In 1855, Todd was appointed superintendent of telegraphs and government astronomer of South Australia. When he arrived in Adelaide, his department was small and without a single telegraph line. Under Todd's direction, important telegraphic links were established with Melbourne and Perth in addition to the Overland Telegraph to Darwin. Todd was appointed postmaster general in 1870. As government astronomer, Todd contributed valuable observations to the scientific world. He retired in 1906.

Todd, Sir Garfield (1908-), a New Zealand-born missionary, was prime minister of Southern Rhodesia (now Zimbabwe) from 1953 to 1958. In the 1960's and 1970's, he was placed under house arrest for his opposition to Ian Smith's illegal regime and for his advocacy of black majority rule. From 1980 to 1986, he served as a member of the senate of Zimbabwe.

Todd, Mark (1956-), a New Zealand horse rider, won an Olympic gold medal in the three-day equestrian event at the Los Angeles Olympic Games in 1984 and in the same event at the Seoul Olympic Games in 1988. Mark Todd was born at Cambridge, New Zealand. In 1980, he became the first overseas rider in 15 years to win the Badminton three-day event in England.

Todd, Mary. See **Lincoln, Mary Todd.**

Toddler. See **Child** (The toddler stage).

Toddy palm is any one of several palm trees that contain a sugary sap that can be used to make the fermented drink called *toddy.* The best-known toddy palms are *wine,* or *fish-tail, palms,* which grow in India and Malaysia. Wine palms bear curious leaves that consist of many fishtail-shaped leaflets. When young flowering shoots are cut off, up to 27 litres of sap a day flows out from each tree. The pith in the stem is a source of sago. See **Sago.**

Scientific classification. Toddy palms belong to the palm family, *Palmae* (Arecaceae), genus *Caryota.*

Toe. See **Foot.**

Tofu is a food made of soybean curds pressed into cakes or blocks. Tofu originated in China more than 1,000 years ago. Today, it is a major source of protein throughout east Asia.

Tofu, formerly known as *bean curd,* resembles custard or a soft white cheese. It has little taste of its own, but it picks up the flavours of the foods it is cooked with. Tofu contains no cholesterol, and it is low in salt and calories.

Many Western-style dishes may be made with tofu, and since the mid-1970's, it has become increasingly popular in the United States. Tofu may be substituted for sour cream in dips and dressings, for minced beef in hamburgers, and for ham or cheese in sandwiches. It also may be used in place of cream cheese in cheesecake and cream in ice cream.

Toga was the outer garment worn by the citizens of ancient Rome. It had a semicircular or oval shape. The toga was wrapped around the body and allowed to fall to the feet in graceful folds. It was usually worn over a loose shirt called a *tunic* that hung to the knees or below. The Romans wore high shoes called *calcei* with the toga. At first, both men and women wore togas. Later, women wore a cloak called a *palla* instead.

Marble statue (A.D. 68-96) by an unknown artist; Galleria Borghese, Rome

A Roman toga was worn by Emperor Augustus, *above.*

Over the years, the Romans changed the size of the toga and the manner of draping it. The earliest togas were short, like the Etruscan garment on which they were based. Later, togas became larger, heavier, and more cumbersome, as elaborate ways were developed to hold them more securely in place. Togas eventually became wide enough to wrap around the body two or three times.

The Romans used soft woollen fabrics to make togas. The ordinary citizen usually wore an unbleached white toga. Coloured borders or coloured fabric showed rank or station. For example, a candidate for public office wore a bleached, brilliantly white toga called the *toga candida.* Public officials and some priests wore a purple-bordered white toga called the *toga praetexta* at government functions. Boys also wore the fancy *toga praetexta* until they put on the natural white *toga virilis,* or *toga of manhood,* at about the age of 14 to 17. Generals wore a richly decorated purple toga called the *toga purpurea,* or *toga picta,* during celebrations of military victories. From the time of Augustus, who ruled from 27 B.C. to A.D. 14, only the emperor wore the purple toga.

Togo is a small country in western Africa. Togo is long and narrow. It extends about 587 kilometres inland from the Gulf of Guinea, an arm of the Atlantic Ocean. It is only 64 kilometres wide at the coast and 145 kilometres wide at its widest point.

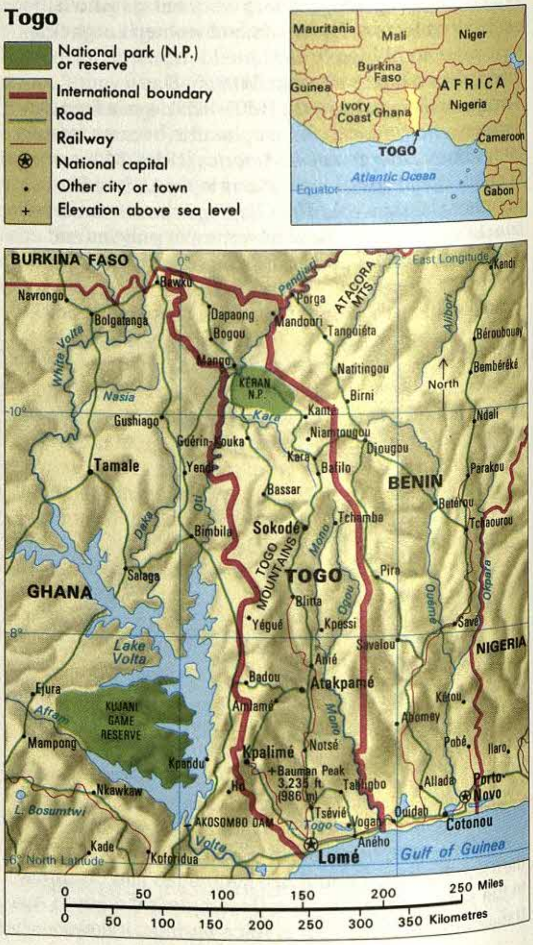
Most of the people of Togo work as farmers. But farm production is small, and many people grow only enough food to feed their families. Lomé, which has a population of about 366,000, is the capital and the only large city. Togo's name in French, the official language, is *République du Togo* (Republic of Togo). *Togo* means *behind the sea* in Ewe, the most commonly used language in Togo.

Government. In 1967, army officers led by Lieutenant Colonel Gnassingbe Eyadema overthrew Togo's civilian government. They suspended the Constitution and dissolved the National Assembly (parliament). Eyadema became president and set up a government. In 1991, a national political conference installed a prime minister and a transitional government. In the country's first multiparty elections in 1993, Eyadema was confirmed as president. See *History* section for details.

People. The ways of life in Togo reflect the fact that several different groups of people have settled the country. But the people are similar in physical type, occupation, and religion. Almost all of them are black Africans. About four-fifths of the people live in rural areas and work on family-owned farms. About three-fifths practise traditional African religions. But dress, language, and other ways of life differ throughout Togo, especially between the south and the north.

The ancestors of the people in southern Togo came from Benin and Ghana. The traditional life of southern Togo is similar to that of those two countries. Many southerners wear a toga, a full-length, loose-fitting garment. Many live in *compounds* (groups of huts inside walls). They speak the Ewe language.

Togo



Facts in brief about Togo

Capital: Lomé.
Official language: French.
Area: 56,785 km². *Greatest distances*—north-south, 587 km; east-west, 145 km. *Coastline*—64 km.
Population: *Estimated 1996 population*—4,264,000; density, 70 people per km²; distribution, 74 per cent rural, 26 per cent urban. *1981 census*—2,705,250. *Estimated 2001 population*—4,959,000.
Chief products: *Agriculture*—cacao, cassava, coffee, cotton, maize, millet, palm kernels and oil, peanuts, sorghum, yams. *Mining*—phosphates.
Flag: The flag has five horizontal stripes, three green and two yellow, with a white star on a red square in the upper left corner. Green symbolizes hope and agriculture; yellow, faith; white, purity; and red, charity and fidelity. See **Flag** (picture: Flags of Africa).
Money: *Currency unit*—franc. One franc=100 centimes.

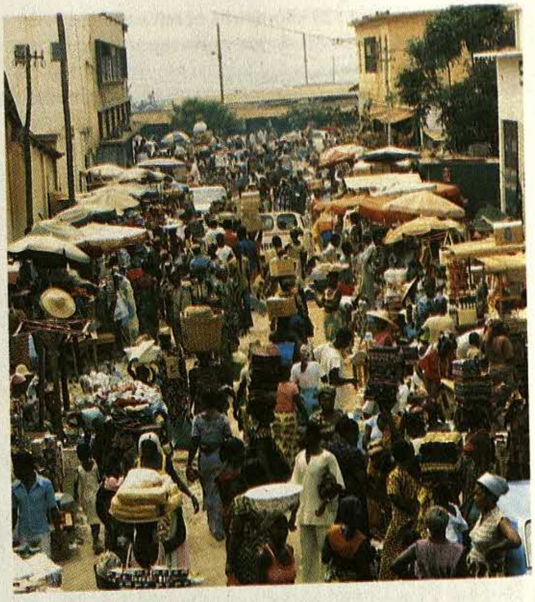
European influence has been greater in the south than in the north. It has affected dress, occupation, and religion. Many southerners wear European-style clothes. Some work for the government, and others have small businesses. Most of Togo's 800,000 Christians, mostly Roman Catholics, live in the south.

Northern Togo was settled by people from the West African savanna region, and its way of life is similar to that of Burkina Faso and Niger. Northerners live in villages made up of adobe houses with cone-shaped thatched roofs. Most wear a white cotton smock. Many languages are spoken in northern Togo. Most of Togo's 250,000 Muslims live in the north.

About 70 per cent of Togo children attend primary school. Only about 20 per cent go to secondary school. Togo has one university, the University of Bénin in Lomé. Many students study abroad, especially in French universities.

Land. The Togo Mountains divide Togo into two major regions. The mountains stretch from southwest to northeast and cover much of western Togo. Bauman Peak (986 metres) is Togo's highest point.

A farmworker in Togo carries a basket of food on her head. Major food crops include cassava, maize, and millet.



Lomé, the capital of Togo, lies at the far southern end of the country. Many southerners, including the people in this marketplace, wear long, loose-fitting garments of colourful fabric.

East and south of the Togo Mountains, the land descends across a sloping plateau to a low, sandy coastal plain. The plateau is covered with tall grass and clumps of hardwood trees. It is drained by the Mono River. The densely populated coastal plain is dotted with swamps, lagoons, and coconut and oil palm forests.

North of the Togo Mountains, the land descends through rolling grasslands to the border of Burkina Faso. The Oti River drains the region. Few people live there. Thorny trees are scattered across the grasslands.

Togo has a hot, humid climate. The temperature averages about 27 °C, and rainfall averages about 100 centimetres a year in the north and 180 centimetres in the south. Rainy seasons last from March to July and September to November in the south, and from April to October in the north.

Economy. Togo is an agricultural country. But good land is scarce, harvests small, and income is low.

Food crops are the most important farm products. They include cassava, maize, millet, sorghum, and yams. The principal crops raised for export are coffee and cacao. Togo also exports peanuts, cotton, *copra* (dried coconut meat), and the *kernels* (nuts) and oil from oil palms. Most of the farms that raise crops for food are owned in common by a group of families. Most of the crops that are sold are grown on small farms owned by individuals. Many Togolese work on these farms as *sharecroppers.* That is, they farm the land and give the landowner part of the receipts. Fishing is an important coastal industry. Togo has one of the world's largest phosphate reserves, and phosphates are Togo's most valuable export.

Togo has little manufacturing. A cement plant, a petroleum refinery, and a large textile mill operate there.

Togo has about 525 kilometres of railways and 7,850 kilometres of roads. An airport and seaport are at Lomé.

History. Ancestors of the central mountain peoples were probably the original inhabitants of Togo. In the 1300's, Ewe-speaking people moved into what is now southern Togo and Ghana. Invaders from the north and refugees from wars in Ghana and Dahomey (now Benin) settled in Togo between the 1500's and 1800's.

Portuguese explorers and traders arrived on the coast in the late 1400's. Between the 1600's and 1800's, European slave-traders raided the coast to capture slaves, and Togo became known as the *Coast of Slaves.*

German traders and missionaries went to Togo in the mid-1800's. In 1884, Germany set up a small protectorate on the coast. By 1899, German Togo included what is now Togo and part of what is now Ghana.

British and French troops occupied German Togo in 1914, after World War I began. In 1919, Britain, also called the United Kingdom (UK), gained control of the western one-third of German Togo and France gained control of the eastern two-thirds. In 1922, the League of Nations confirmed a *mandate* (authority to govern) for the UK over British Togoland and for France over French Togoland. The United Nations changed the mandates to *trusteeships* (UN authority to govern) in 1946. In 1956, the people of British Togoland voted to join the Gold Coast. When the Gold Coast became independent as Ghana in 1957, it incorporated British Togoland.

After World War II (1939-1945), an independence movement developed in French Togoland. Sylvanus Olympio, leader of the Committee for Togolese Unity Party (CTU), wanted complete independence from France. Nicolas Grunitzky, leader of the Togolese Party for Progress, wanted to remain in the French Union.

In 1956, France gave French Togoland internal self-government, but the UN refused to accept this method of ending the trusteeship. In a UN-supervised election in 1958, the CTU won control of the legislature and Olympio became prime minister. The Republic of Togo was created on April 27, 1960, with Olympio as president.

Rivalry between northerners and southerners has always been important in Togo's politics. In 1963, northern army officers assassinated Olympio, a southerner. They made Grunitzky president. Grunitzky was from the south, but he opposed Olympio and the CTU. Southern CTU members tried unsuccessfully in 1966 to oust him.

Army officers led by Gnassingbe Eyadema overthrew Grunitzky's government in January 1967. They suspended the constitution and set up a government with Eyadema as president. The Rally of the Togolese People, headed by Eyadema, was created as the country's only legal party in 1969. The people endorsed Eyadema as president in a vote taken in 1972 and reelected him in 1979.

In 1991, after strikes and protests demanding reform, a national political conference was held. The conference stripped Eyadema of his executive powers and installed a prime minister and transitional government. In the country's first multiparty elections, Eyadema was confirmed as president.

See also **Lomé.**

Toilet. See **Plumbing.**

Tojo, Hideki (1884-1948), was the general who, as premier, led Japan into war with the United States in 1941. In 1937, he was chief of staff of Japan's Kwantung Army, which had gained control of Manchuria.

Tojo was one of a group of militarists who objected to democratic developments within Japan. By provoking "incidents," the militarists tried to commit their home government to decisive steps. In this manner, they had engineered the Manchurian Incident, an explosion on a Japanese-run railway in Manchuria in 1931. The militarists blamed the Chinese for the explosion and used it as an excuse to occupy Manchuria. The incident was the first of a series of aggressive acts that led to a conflict called the second Chinese-Japanese War (1937-1945).

The United States applied economic pressure to halt the Japanese aggression. Tojo and other Japanese militarists became convinced that Japan would have to fight the United States in order to secure access to the raw materials of European colonies in Southeast Asia. By 1936, military leaders had firm control of Japan's government.

Hideki Tojo

Tojo rose rapidly during the confusion of the 1930's. In 1940, he became minister of war. When German dictator Adolf Hitler seemed to be winning World War II (1939-1945), Tojo threw his weight behind Hitler and Benito Mussolini and against the democracies. As American embargoes on oil to Japan began to strain the Japanese economy, Tojo insisted that if an agreement with the United States could not be reached, Japan would have to fight. In October 1941, Tojo succeeded Prince Konoye as premier. When talks in Washington, D.C., failed to bring results, Tojo decided on war.

Tojo's popularity in Japan was high after the early victories of World War II, but his influence waned as American victories in 1943 and 1944 began to turn the tide. He was forced to resign as premier in 1944 after the fall of Saipan. He was convicted as a war criminal after Japan's surrender and was hanged on Dec. 23, 1948. Tojo was born the son of a general in Tokyo. His background, training, and interests were exclusively military.

See also **Japan** (History).

Tokamak. See **Nuclear energy** (Nuclear energy today).

Tokelau is a group of three coral atolls situated in the South Pacific Ocean about 480 kilometres to the north of Samoa. The total population of Tokelau is about 2,000. The islands were previously known as the *Tokelau Islands* and also as the *Union Islands.* They have a total land area of 10 square kilometres. The language of the Tokelauans is related to Samoan. The people also speak English. The only export of any significance is copra.

The British navigator Commodore John Byron visited Atafu in 1765. In 1889, a British protectorate was proclaimed over the three atolls, which became known as the Union Islands. They were made part of the Gilbert and Ellice Islands Protectorate in 1916. New Zealand took over the administration of the Tokelau Islands in 1926, and they became a part of New Zealand in 1948.

Tokyo's Imperial Palace Plaza, *foreground,* adds beauty and charm to the busy central section of the city. Tokyo, one of the world's largest cities, is one of the most crowded places on earth. But it has many scenic open areas like the plaza.

Tokyo

Tokyo is the capital of Japan. About $8\frac{1}{4}$ million people live in the city proper of Tokyo. Tokyo is also the chief city in the most populous urban centre in the world (see **City** [table]). In 1995, the Tokyo-Yokohama area had an estimated population of over 28 million people.

Tokyo is the main business centre of Japan as well as the home of the Japanese emperor and the headquarters of the national government. The city has many banks, commercial establishments, and industries. These institutions help make Japan one of the richest nations in the world.

Tokyo has tall buildings, motorways jammed with traffic, and more neon signs than any other city in the world. Tokyo teenagers dance to Western hit tunes, and the city's restaurants offer everything from hamburgers to the finest European dishes. Many residents of Tokyo go to baseball games and watch films and television shows from Western countries. Theatrical works, operas, and other Western forms of dance and music are performed regularly. But in spite of such outside influences, Japanese tradition remains strong in Tokyo. Many of the people enjoy going to city parks to admire their beautiful cherry trees and lotus blossoms. These and other attractive sights in the city reflect the Japanese love of beauty. Large numbers of Tokyo's people take part in dances and parades during the city's many traditional festivals, some of which have been held for hundreds of years. They visit historic shrines and temples and attend old-style plays and wrestling matches.

Tokyo traces its beginning to 1457, when a powerful warrior built a castle there. It became the Japanese capital in 1868. Tokyo has twice been almost destroyed—by a terrible earthquake in 1923 and by air raids in the 1940's during World War II.

About 7 per cent of Japan's people live in Tokyo. The city has become so crowded that it has a severe housing shortage. Tokyo's rapid growth also created other problems, including some of the world's worst pollution and heaviest traffic.

Facts in brief about Tokyo

Population: *City proper*—8,163,573. *Metropolitan area population*—11,927,457.

Area: *City proper*—578 km^2; *Metropolitan area*—2,156 km^2.

Altitude: 24 m above sea level.

Climate: *Average temperature*—January, 4 °C; July, 24 °C. *Average annual precipitation* (rainfall, melted snow, and other forms of moisture)—147 cm.

Government: *Chief executive*—governor (4-year term). *Legislature*—126-member assembly (4-year terms).

Founded: 1457.

Tokyo *A city of growth. World's third largest city, and an economic leader.*

The Imperial Palace, *left,* is the home of Japan's emperor. It stands near the centre of Tokyo. Stone walls and wide moats separate it from the rest of the city. Thousands of people visit the palace each year on January 2 and the emperor's birthday—the only days it is open to the public.

Japan's capital and largest city (pop. of city proper 8,163,573). National centre of finance, commerce, industry, transportation.

Home of the Japanese emperor. Imperial Palace beautifies crowded central Tokyo.

Many Western influences: clothing styles, popular music, restaurant fare. But Japanese tradition still strong: many traditional festivals, historic shrines and temples, *no* and *kabuki* plays, *sumo* wrestling.

The Ginza District, *below,* is one of Tokyo's liveliest areas. Many exclusive department stores and boutiques line its streets. Ginza, the site of a mint from the 1600's to 1800 (the word *gin* means silver), became a shopping and entertainment district in the late 1800's. Some of the original stores, including Wako and Mikimoto, are still in business.

Tokyo has played major role in the dramatic growth of Japan's economy since end of World War II in 1945.

About a quarter of nation's businesses have headquarters in Tokyo area. Leading industries include manufacture of electrical machinery, and publishing and printing. Tokyo Stock Exchange is the world's largest. City's rapid commuter trains carry millions of passengers daily.

Cultural institutions of Tokyo reflect culture of both East and West.

Tokyo is national centre of performing arts and motion picture industry. Valuable Asian art collection at Tokyo National Museum, nation's largest museum. National Diet Library is part of national government headquarters.

Baseball ranks as Tokyo's most popular sport. Many important track and field events held at National Stadium.

The Asakusa Kannon Temple, *above,* is one of the country's best-known Buddhist temples. The temple traces its origins back to the A.D. 600's, though the main temple structures were built in the 1950's. Traditional festivals at the temple draw crowds of worshippers. In this colourful scene dancers dressed as tall white herons perform outside the temple. The event is the Shirasaki-no-mai festival.

Meiji Shrine, *below,* is one of Japan's most popular Shinto places of worship. More than two million Japanese visit it on New Year's Day. The *torii* (entrance gate) shown here is one of the largest in Japan.

Tokyo Tower, *left,* the city's tallest structure, rises 333 metres. It houses radio and television broadcasting studios. In addition, two observation platforms offer a fine view of the city.

Tokyo called *Edo* during most of its history—powerful Edo family lived there in the late 1100's.

In 1868, Emperor Mutsuhito renamed the city *Tokyo* (eastern capital) and moved the capital there. Violent earthquake shook Tokyo on Sept. 1, 1923. Heavy bombing during World War II (1939-1945) again brought death and destruction. Economic and population growth followed end of war. But growth also led to housing shortages, traffic jams, and air pollution.

The city

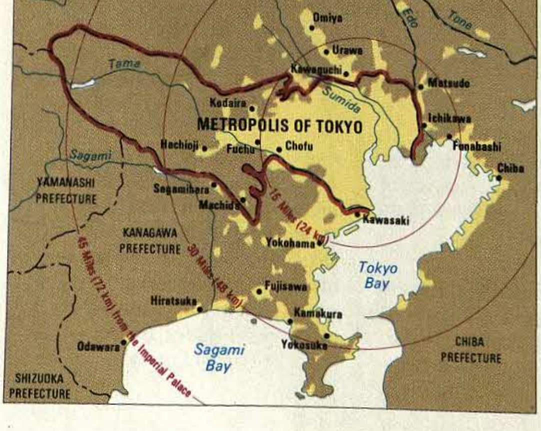
The city of Tokyo, called the *city proper,* covers 578 square kilometres and has a population of 8,163,573. The city is part of a large metropolitan area called the *Metropolis of Tokyo.* The Metropolis includes many communities west of the city. It covers 2,156 square kilometres and has a population of 11,927,457.

The entire metropolitan area operates under the same government. Owing to its single government, the Metropolis of Tokyo is often considered a single community. But this article describes the city proper and outlying areas separately.

The city proper is the busiest, most heavily populated part of the Metropolis. It lies at the northwest end of Tokyo Bay on the Kanto Plain, Japan's largest lowland. The city is bordered by the Edo River on the northeast and the Tama River on the south.

The city proper is divided into 23 units called *wards.* The Japanese word for *ward* is *ku,* and so the city proper is called the *ku area,* or the *ward area.* The Imperial Palace, where the emperor lives, stands amid beautiful parklike grounds on high land near the centre of the city. Eastward, from the palace to the bay, the land is low and flat. Many of Tokyo's chief business, commercial, and industrial districts are in these low-lying areas. Part of eastern Tokyo is jammed with office and apartment buildings made of concrete and steel. For a picture of Tokyo's business centre, see the start of the **City** article. Tokyo's oldest and poorest residential sections are also in the eastern part of the city.

Tokyo lies on Honshu Island in central Japan. The map below shows the Metropolis of Tokyo, which covers the same area as Tokyo Prefecture. Prefectures in Japan are similar to states in the United States or Australia. The map shows built-up areas in yellow.



Much of far eastern Tokyo is filled-in land on what had been part of Tokyo Bay. Some of this land lies below sea level. The low-lying areas are always in danger of floods, especially during heavy rains. Dykes have been built along the waterfront and the river banks. But the filled-in land sinks lower every year, mainly because of the removal of large amounts of ground water for industrial use. The dykes sink along with the land, making flood control difficult.

West of the Imperial Palace, the land becomes hilly. The chief residential sections of the city proper are in the west. The houses include large apartment buildings like those in Western cities and simple one- or two-storey wooden buildings, the traditional Japanese houses. Many of the wooden houses are small and plain by Western standards. In some sections, rich families and poor families live in the same neighbourhood, and their houses are plain and look much alike. But the western part of the city proper also has luxurious residential sections where the wealthy live.

Tokyo, unlike most other Japanese cities, no longer has large numbers of buildings in the ancient Japanese style that is most familiar to Westerners. This style features low, graceful lines and roofs turned up at the edges. Most of the remaining buildings in this style are religious shrines or temples.

Several well-known districts, each with its own characteristics, lie near the Imperial Palace. The Marunouchi district, an area of tall office buildings southeast of the palace, is Tokyo's business and financial centre. The Ginza district lies farther south. It ranks as one of Tokyo's liveliest and most colourful districts and is famous for its shops and nightclubs. The Kanda district, northeast of the palace, is famous for its many bookshops. The Asakusa district, north of Kanda, is one of Tokyo's oldest entertainment sections. It features amusement parks, theatres, and restaurants.

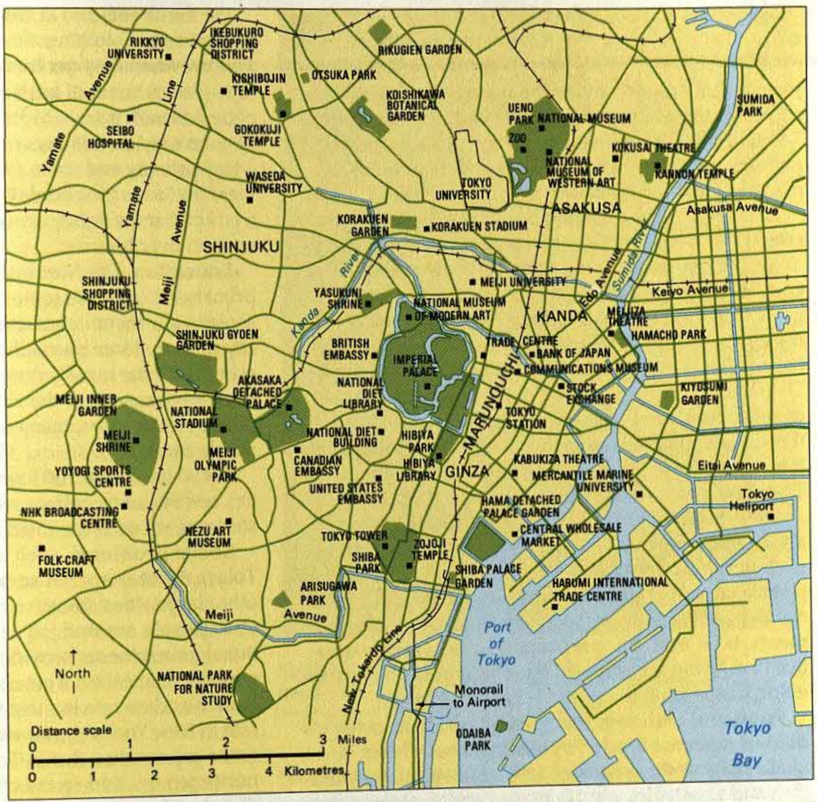
Only main streets in Tokyo have names. Instead of street names, Tokyo addresses give the names of wards and other districts. A ward, called a *ku,* is divided into sections or neighbourhoods, each of which has a name. These sections are divided into *subdivisions* (groups of blocks) called *chome,* which are numbered. Each block in a chome has a number, as does each house or cluster of houses in a block. The address *2-7, Yamabuki 1-chome, Shinjuku-ku* stands for *block 2, house 7, subdivision 1 in the Yamabuki section of Shinjuku ward.*

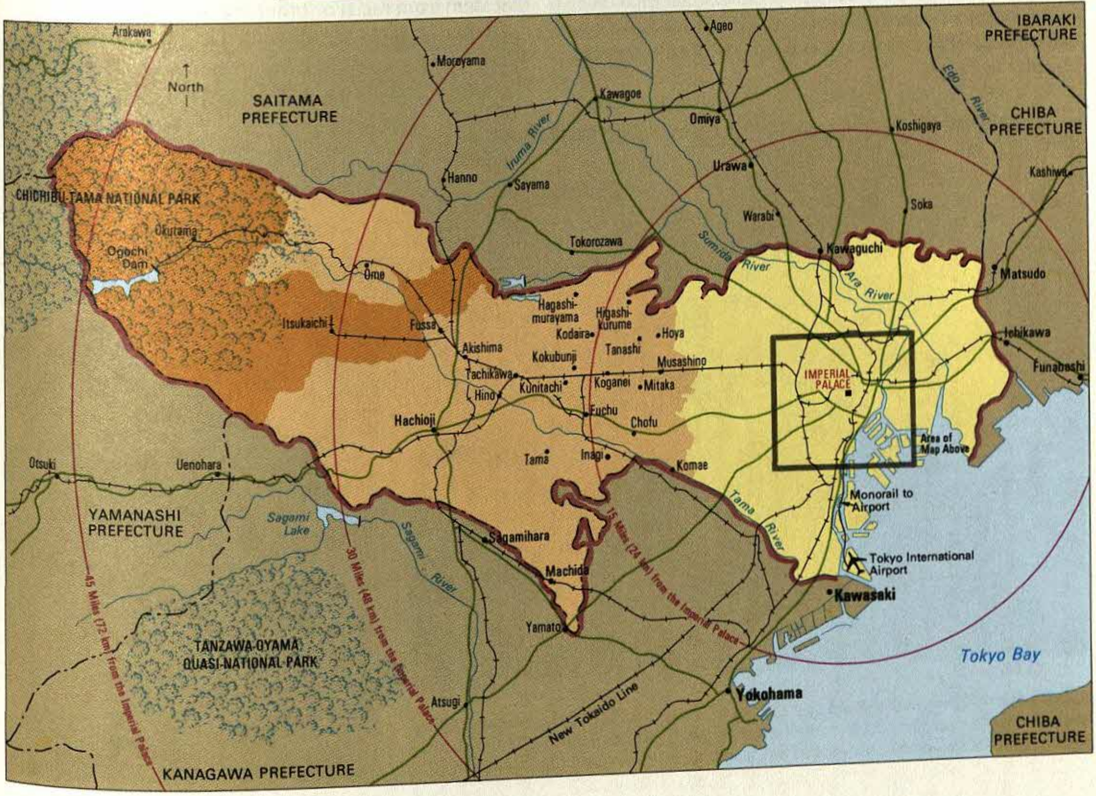
Outlying areas. In addition to the city proper, the Metropolis of Tokyo includes 26 suburban cities and 1 county area. The suburban cities extend westward from the city proper. The county area, which lies in the westernmost part of the Metropolis, includes several towns and villages as well as farms and forests. Two small island groups in the Pacific Ocean are also part of the Metropolis. They are the Izu Islands and the Bonin Islands. The Bonin Islands form an archipelago of 97 volcanic islands that lie some 800 kilometres due south of Tokyo. Nearly 2,000 people live on the 106 square kilometres that make up the land area of the islands.

Tokyo

The map on the right shows central Tokyo and its major landmarks. The map below shows the Metropolis of *Tokyo,* which includes the city proper and the suburban and county areas. Each area appears on the map in a different colour. The red circles show distances from the Imperial Palace.

- ━ Metropolis boundary
- - - - Prefecture boundary
- ━ Road or street
- ┼┼ Railway
- • City or town
- ▪ Point of interest
- 🟨 City proper
- 🟧 Suburban area
- 🟫 County area
- 🟩 Park or garden
- ▨ National park





The people

More jobs and educational and cultural opportunities are available in Tokyo than anywhere else in Japan. As a result, the city constantly attracts people—especially the young—from other parts of the country. Between 1960 and 1980, the Metropolis gained nearly 2 million people. Today, Tokyo proper has an average of about 14,000 persons per square kilometre—nearly three times as many as crowded Bombay has.

Housing. Tokyo's soaring population has created a serious housing shortage. In the past, most Tokyo residents lived in small, one- or two-storey wooden houses, each with its own yard or garden. As the population grew, many apartment buildings were constructed in the city proper in an attempt to provide housing for all the people. Even so, the housing shortage continued. The shortage of housing and of land in the city proper drove up rents and land prices. Many people—even if they could find housing in the city proper—could not afford to pay for it. As a result, a building boom began in Tokyo's outlying areas during the mid-1900's.

The city government has begun financing the construction of low-rent, low-cost housing projects. One such project, called Tama New Town, will house 400,000 people after its completion in the mid-1990's. But Tama New Town, like many other Tokyo housing developments, is far from the city proper. Some workers who live in outlying areas spend up to four hours a day travelling to and from their jobs in central Tokyo.

Food and clothing. Many Tokyo residents enjoy traditional Japanese foods. Popular Japanese dishes include *sukiyaki* (beef cooked with vegetables), *tempura* (fish and vegetables fried in batter), and *sushi* (rice flavoured with vinegar and mixed with other food, such as fish or vegetables). Western and Chinese foods are also popular in Tokyo.

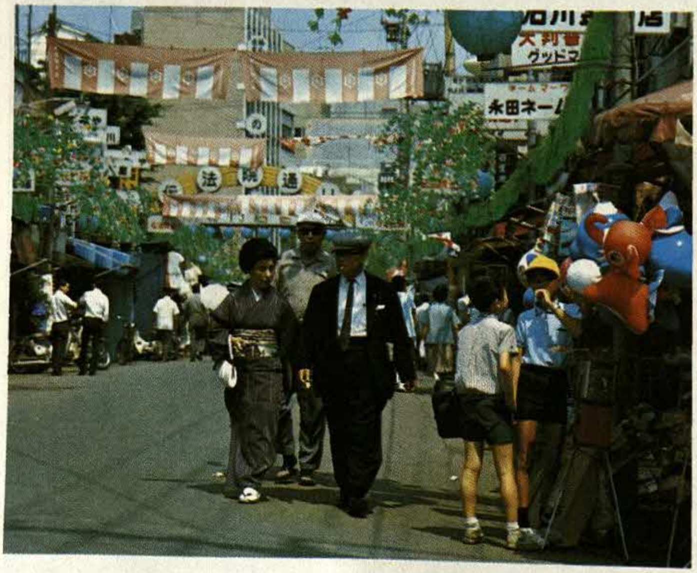
On the streets and at work, most of the people wear Western-style clothing. Some older people still put on a *kimono* when they get home. The kimono, a traditional Japanese garment of both men and women, is a long robe tied with a sash. Most Tokyo young people wear a kimono only on holidays or other special occasions. Many primary and some secondary school students wear uniforms to school. The boys' uniform is a suit with a jacket that fits tightly around the neck. Girls wear skirts and pullover blouses.

Education. The Metropolis of Tokyo has about 1,200 primary schools, 700 junior secondary schools, and 400 senior high schools. Most of these schools are in the city proper. Some parts of Tokyo do not have enough schools for the rapidly growing population. However, in some old sections of the city that are now largely occupied by businesses, many of the school buildings stand nearly empty.

Tokyo has about 100 four-year colleges and universities and 90 junior colleges. About half of Japan's college students attend these institutions.

Social problems, such as poverty and crime, exist in Tokyo. But they are not so severe as they are in many other large cities. Because of Tokyo's strong economy, most people can find jobs. In addition, the local and national governments provide aid for people who cannot support themselves. Tokyo's crime rate is much lower than the crime rate in most Western cities. The robbery rate in New York City, for example, is more than 150 times greater than that in Tokyo. Tokyo has no large minority groups, and so the city is not troubled by conflicts that stem from racial or other social differences.

Demonstrations are often held in Tokyo to protest against such matters as political and educational policies. They have sometimes resulted in violence.



Life in Tokyo combines the old and the new. Some people, like the woman above, wear the traditional kimono. But most wear Western clothes. Housing in the city includes both old wooden houses and modern high-rise apartment buildings, *right.*

Few cities in the world can match Tokyo as a *cosmopolitan* (international) cultural centre. Tokyo's art galleries, concert halls, museums, and other cultural institutions reflect the culture of both the East and the West.

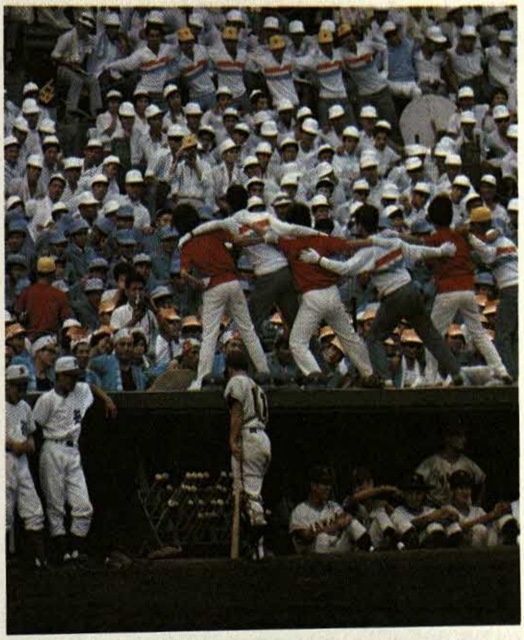
Arts. Many of Japan's finest artists and craftworkers live and work in Tokyo. Some still use the styles and methods of their ancestors to create beautiful paintings on paper or silk and colourful woodblock prints. But many Tokyo artists create paintings and sculptures using Western styles and methods.

Tokyo is the centre of Japan's performing arts, such as drama and music. Two traditional types of Japanese drama, *no* and *kabuki,* rank as favourite forms of entertainment in Tokyo. For descriptions of these colourful plays, see **Drama** (Japan). Five professional symphony orchestras that specialize in Western music perform in Tokyo. Other Tokyo musical groups present concerts of traditional music, featuring such Japanese instruments as the three-stringed *samisen,* or *shamisen,* and a kind of harp called a *koto.* Japan's film industry is also centred in Tokyo. Japanese films have been praised by audiences throughout the world.

Museums and libraries. Some of Japan's finest museums and libraries are in Tokyo. The Tokyo National Museum, the largest museum in Japan, has a valuable collection of Asian art objects. The National Museum of Modern Art specializes in works by modern Japanese artists. The National Museum of Western Art houses a large collection of works by Western artists.

Tokyo's public library system includes a central library and more than 70 branch libraries. The National Diet Library, which is part of the headquarters of Japan's national government, ranks as the country's largest library. It owns about 6 million volumes, and its functions resemble those of the British Library (see **British Library**).

Japan's performing arts are centred in Tokyo. Traditional art forms, such as the *no* drama, *above,* are popular. However, Western-style drama and music also draw large crowds.



Sporting events rank among Tokyo's chief forms of entertainment. Many people, like those above, are baseball fans. Many also enjoy sumo wrestling and other ancient Japanese sports.

Entertainment and recreation. Tokyo offers a wide variety of leisure-time activities. Concerts, films, and plays attract large audiences. Exhibitions of *judo* and *sumo,* which are Japanese forms of wrestling, rank as favourite sporting events. Western sports, including athletics, baseball, golf, ice skating, tennis, and tenpin bowling, are also popular. Baseball is the most popular sport in Tokyo. Home games of the Tokyo Giants professional baseball team and many other sports events are held in the 35,000-seat Korakuen Stadium. Tokyo's largest stadium, the National Stadium, is the site of many important athletics events. The stadium seats about 72,000 spectators.

Tokyo also has many amusement parks and nightclubs. At some of the older Japanese-style restaurants, talented young women called *geishas* entertain patrons with singing, dancing, and conversation.

Almost all Tokyo families own a TV set. Both Japanese programmes and American and European programmes with Japanese soundtracks appear on Tokyo TV.

Religion. Shinto and Buddhism are the chief religions throughout Japan. Tokyo has hundreds of historic Shinto shrines and Buddhist temples. But most Tokyo residents visit these places of worship only for public festivals or such special occasions as weddings and funerals. Less than 2 per cent of the residents of the Metropolis are Christians.

Visiting Tokyo

Large numbers of tourists visit Tokyo throughout the year. In early April, the city's famous cherry trees are in bloom. Autumn in Tokyo usually brings pleasantly mild weather. The city's many festivals are other tourist attractions. These include the exciting parade of Tokyo's firemen on January 6 and the lively festival of the Asakusa Shrine in mid-May.

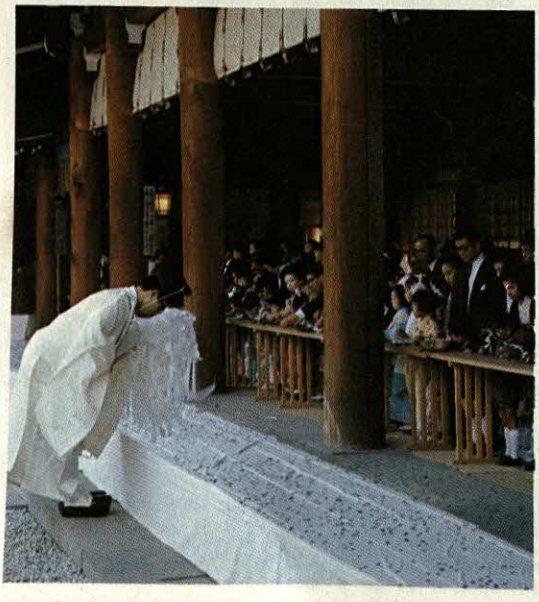
Tourists can choose from many fine hotels and restaurants in Tokyo. Many of the hotels are built and furnished in Western style. Others are Japanese-style hotels called *ryokan.* They have such traditional features as sliding paper-panelled doors, *tatami* mats that cover the floors, and heavy quilts called *futons* that serve as beds. Tokyo has an unusually large number of restaurants—more than 60,000. Some of these restaurants specialize in Western or Chinese foods, and others serve only Japanese dishes.

This section of the article describes a few of the interesting places to visit in Tokyo. Other sections discuss additional places of interest.

The Imperial Palace is the home of Japan's emperor. It stands near the centre of the city proper and consists of several low buildings and beautiful parklike grounds. Stone walls and a series of wide moats separate it from the rest of the city. The palace is open to the public only on two days of the year—January 2 and the emperor's birthday. Thousands of Japanese come to pay their respects to the emperor on these two days.

The National Diet Building, a concrete and granite structure with a tall central tower, stands southwest of the Imperial Palace. It is the meeting place of Japan's *Diet* (parliament) and is open to visitors.

Tokyo Tower, a 333-metre steel tower, stands about 2.5 kilometres south of the Imperial Palace. The city's tallest structure, Tokyo Tower houses radio and television broadcasting studios and has two observation platforms.



At Tokyo's famous Meiji Shrine, Shinto priests greet visitors with a bow. This shrine and other historic places of worship are among Tokyo's leading tourist attractions.

The Imperial Palace attracts thousands of visitors on January 2 and the emperor's birthday, when it is open to the public. A family poses for a photograph near the palace grounds, *above.*

Parks and gardens of Tokyo attract many visitors. Ueno Park, about 3 kilometres northeast of the palace, is one of the city's most popular parks. Its spring displays of cherry blossoms and summer displays of lotus blossoms are outstanding. The park includes Tokyo's largest concert hall, several museums and art galleries, a zoo, a temple and shrine built during the 1600's, and tombs of Japanese rulers.

Several Japanese-style gardens in Tokyo are open to the public. Korakuen Garden and Rikugien Garden—both a little north of the palace—are two of the oldest and most famous gardens. Many people visit Tokyo's gardens to admire their beautifully landscaped grounds and to relax at their teahouses.

Shrines and temples attract millions of worshippers and tourists yearly. The shrines are Shinto places of worship, and the temples are Buddhist. Meiji Shrine, about 5 kilometres southwest of the Imperial Palace, is one of the best-known shrines in Japan. Many Japanese visit it on New Year's Day, one of the few times when most Japanese women wear traditional dress in public. The Yasukuni Shrine stands northwest of the palace. It is dedicated to Japan's war dead and draws huge crowds of worshippers for special festivals in April and October. Tokyo also has a number of famous Buddhist temples, including the historic Kannon Temple in the Asakusa district. The temple traces its origins to the 600's, though the present buildings were constructed in the 1950's. Brightly decorated souvenir shops line the approach to the temple.

Economy

Tokyo ranks as one of the world's centres of economic activity. Since the end of World War II in 1945, Japan's economy has grown faster than that of any other country. Tokyo has played a major role in this growth. It is the main centre of Japan's commercial, financial, and industrial activities and of its transportation industry. About a quarter of Japan's business corporations have their headquarters in the Metropolis. About 15 per cent of all the factories in Japan are also there.

Industry. The Tokyo Metropolis has 80,000 factories. Most of them are small and employ fewer than 20 people. However, some are gigantic plants that have from 10,000 to 20,000 workers. Nearly 1 ½ million industrial workers hold jobs in the Tokyo Metropolis.

Tokyo's two leading industries are (1) the manufacture of electronics equipment and (2) publishing and printing. Several huge companies and many small ones in the Metropolis make cassette recorders, compact disc players, computers, facsimile (fax) machines, radios, television sets, video recorders, and other electronics equipment. Many of these products are exported to most parts of the world. About four out of every five Japanese publishing companies have their headquarters in Tokyo. The Tokyo area's newspaper companies publish more than 25 daily papers and sell a total of about 25 million copies daily. Much of the material published in Tokyo is also printed there. Other important products of Tokyo include chemicals, food, furniture, and paper. Several Tokyo companies rank among the 25 largest manufacturing firms in the world.

Finance. Businesses and industries throughout Japan depend on Tokyo banks for loans. The Bank of Japan, the nation's central bank, has its headquarters in Tokyo. Controlled by the national government, the Bank of Japan regulates the nation's entire banking system. Tokyo also has many commercial banks. The largest commercial banks have branches or offices in many Japanese and foreign cities.

The Tokyo Stock Exchange is one of the world's leading stock exchanges. It has about 100 members and lists about 1,070 stocks.

Trade. Nearly 3,000 companies in the Tokyo Metropolis deal in foreign trade. These firms handle almost half of Japan's export business and more than half of the nation's import business. The 40-storey Tokyo Trade Centre displays various types of Japanese goods for foreign buyers.

About 173,000 wholesale and retail establishments are in the Metropolis. The 41,000 wholesale companies, which sell to buyers throughout Japan, employ more than 600,000 people. The 132,000 retail shops employ more than 550,000 workers. Most of the retail shops are small. But Tokyo has department stores and shopping centres that are as large, attractive, and modern as any in the world.

Transportation. About 2 million motor vehicles are registered in the Metropolis. Most are cars. In the mid-1900's, the metropolitan government built a system of motorways to speed traffic through the city. Even so, there are many more motor vehicles than the motorways and streets can handle, and severe traffic jams occur frequently. The metropolitan government is trying to provide more public transportation as a substitute for private car travel.

The Tokyo Stock Exchange, *above,* is one of the world's leading stock exchanges. The exchange and the city's many banks help make Tokyo the financial centre of Japan.

The manufacture of electrical machinery is Tokyo's leading industry. Many electrical products made in Tokyo, including video recorders, *above,* are exported to other countries.

Tokyo's public transportation system is a complicated network of railway, underground, and bus lines. Railways extend to most outlying areas and to other parts of Japan. Japanese National Railways operates some of the lines, and the rest are privately owned. Tokyo's commuter trains rank among the fastest and most efficient in the world. Nearly 10 million passengers cram aboard them each day and about 3 million use the trains of the city's seven underground lines daily. Employees called *pushers* work at some train stations. Their job involves shoving passengers into crowded trains to make more room (see **City** [picture: Travel in cities]). One of the world's few successful *monorails* (single-rail trains) carries passengers between central Tokyo and Tokyo International Airport, in the far southern part of the city. Buses carry about 6 million passengers daily.

About 20 major airlines offer scheduled flights between Tokyo International Airport, also called Haneda Airport, and foreign cities. Air travel in and out of Tokyo is heavy, and so a much larger airport had to be built. The New Tokyo International Airport, also called Narita Airport, is located about 64 kilometres northeast of central Tokyo. It was completed in 1973. However, the opening of the airport was delayed because of strong, sometimes violent, protests by nearby residents and others who objected to the airport's presence. The airport opened in 1978.

The Port of Tokyo is not one of Japan's leading ports. Other ports, including those of Kobe and Yokohama, have deeper harbours and therefore can handle larger ships. Much of Tokyo's sea trade passes through the nearby Port of Yokohama. Railways, trucks, and barges carry large quantities of freight between the two cities.

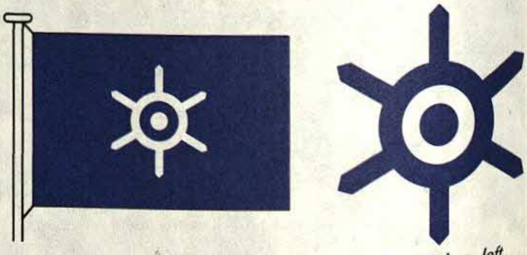
Government

Organization. The Metropolis of Tokyo is treated like one of Japan's *prefectures.* A prefecture is somewhat like a state of the United States or Australia. The government of the Metropolis serves as the government for the prefecture and for the city proper and the rest of the metropolitan area.

The governor of Tokyo serves as the chief government official of the Metropolis of Tokyo. The people elect the governor to a four-year term. Tokyo's chief lawmaking body is the Metropolitan Assembly. It has 126 members, whom the voters elect to four-year terms. Each ward, city, and other community in the Metropolis has at least one representative in the Assembly. The metropolitan government also includes the board of education, the police force and fire brigade, and many other agencies. Together, they employ more than 220,000 people.

The wards, cities, towns, and villages of the Metropolis all have some form of local government. Each elects a council and a mayor or other administrator, but the powers of these officials are limited by the metropolitan government. The metropolitan government makes *ordinances* (rules) for all the communities in the Metropolis. It also provides police protection and certain other public services for the entire Metropolis. But it provides some services, including fire protection and sanitation facilities, for the city proper only. Local governments must provide services not supplied by the metropolitan government. They may collect some tax money for these projects, and they receive additional funds from the metropolitan and national governments.

Problems. Tokyo, like cities everywhere, faces enormous problems. The metropolitan government must deal with such problems as a severe housing shortage, air and water pollution, overcrowded streets and main roads, and danger from floods and earthquakes. Tokyo's complicated government organization and a shortage of money make solutions to the problems difficult. The metropolitan government has a responsibility to both the national government and the people of the Metropolis. This double responsibility complicates the metropolitan government's work. In addition, much of the tax money collected in the Metropolis goes to the national government. Many Tokyo government officials believe that the national government should make the duties of the metropolitan government simpler and give the Metropolis more control over its finances.



Symbols of Tokyo. The flag of the Metropolis of Tokyo, *left,* and the coat of arms, *right,* feature a design made from the *kanji* characters used to write the word *Tokyo.* Kanji are Chinese characters used in the Japanese language. The design also represents the sun casting its rays throughout the city.

History

Early development. During most of its history, Tokyo was called *Edo.* The first historical record of a settlement in the area shows that a powerful family named Edo lived there about 1180. The area had military importance because it overlooked both Tokyo Bay and the Kanto Plain. In 1457, a warrior named Ota Dokan built a castle at Edo. Dokan worked in the service of a powerful warrior family, one of several who ruled parts of Japan. He built his castle where the Imperial Palace now stands, and so Tokyo marks 1457 as the year of its beginning. A town named Edo grew up around the castle. But the development that made the town Japan's chief city did not begin until 1590. In that year, a warrior named Tokugawa Ieyasu made Edo his headquarters. In 1603, Ieyasu became *shogun* (military ruler) of Japan, and so Edo became the nation's political centre. But Kyoto, a city southwest of Edo and the home of the emperor, remained the official capital. By the early 1800's, Edo had grown into a city of over a million people—a little smaller than London at that time. Ieyasu and his descendants ruled as shoguns in Edo until 1867.

Western influence. In the early 1600's, Japan closed itself off from normal contact with the rest of the world. This is known as the *sakoku* (closed country) policy. The government allowed ships from Holland and from China to trade in Japan, but only occasionally and only at the port of Nagasaki. It prohibited Japanese people from travelling to other countries. In 1853, Commodore Matthew C. Perry sailed into Tokyo Bay with four warships, on a mission for the U.S. government to open relations with Japan. After talking with Japanese rulers, he returned with more warships the next year and reached a partial agreement with them. Partly as a result of Perry's efforts, Japan signed trade treaties with the United States and other Western countries in 1858. The treaties marked the start of modern Western influence in Japan.

Emperor Mutsuhito—also known as the Meiji Emperor—did much to further Westernization. He took control of Japan from the shogun in 1867. He transferred the capital from Kyoto to Edo in 1868 and moved into the Edo castle. Edo was renamed *Tokyo,* which means *eastern capital.* After 1868, Japan—especially Tokyo—rapidly adopted Western styles and inventions. By the late 1800's, Tokyo began to look like a Western city.

Earthquake and reconstruction. On Sept. 1, 1923, a violent earthquake shook the Tokyo-Yokohama area. Buildings collapsed and fires broke out throughout Tokyo. About 59,000 residents of the city proper died in the disaster, and most of central Tokyo was destroyed. The city was rebuilt during the next 20 years.

At the time of the earthquake, Tokyo consisted of 15 wards in the vicinity of the Imperial Palace. After the tragedy, areas outside the 15 wards began to develop. In 1932, the city took over many of the areas and made them wards, establishing the present ward area.

World War II brought destruction to Tokyo again. American bombers first attacked the city in April 1942. The heaviest raids occurred from March to August of 1945, when Japan announced its intention to surrender. The bombs ruined about 250 square kilometres of Tokyo. Over 250,000 people were killed or listed as missing. Thousands fled the city. Tokyo's population dropped from about 7,350,000 in 1940 to about 3,500,000 in 1945. In 1943, Tokyo and communities west of it formed the Metropolis of Tokyo.

Rebuilding the city. The people of Tokyo began to rebuild their city after the war, but without much planning. Buildings went up wherever there was room. Tokyo's economy began booming a few years after the war. Population growth accompanied economic growth, and the population of the city proper more than doubled between 1945 and 1960. In 1964, Tokyo was host to the summer Olympic Games. In preparation for the games, the city started a construction programme that included new motorways and hotels, and the monorail.

Recent developments. Tokyo's continued growth has made it one of the world's largest cities and has given it a strong economy. But this growth, along with the lack of planning, has helped cause such problems as the housing shortage, pollution, and traffic jams.

In 1969, the metropolitan government started a series of three-year plans to help solve Tokyo's problems. The plans set goals for improving public housing, purifying the polluted air and river water, reducing street noise and traffic jams, and increasing sanitation facilities. Parts of the Metropolis have been set aside for public housing and other community projects. To ease overcrowding, the government encourages the development of new suburban towns.

In 1985, an international exposition called "Tsukuba Expo '85" was held at Tsukuba, a new town about 50 kilometres northwest of Tokyo. Tsukuba has about 50 research institutes and two universities dedicated to technological studies.

Related articles in ***World Book*** include:

Architecture (picture)
Asia (picture: Two Asian street scenes)
Bonin Islands
City (pictures)
Japan (with pictures)
Japanese print
Shogun
World War II (The tide turns; Closing in on Japan)

Outline

I. The city
- A. The city proper
- B. Outlying areas

II. The people
- A. Housing
- B. Food and clothing
- C. Education
- D. Social problems

III. Cultural life
- A. Arts
- B. Museums and libraries
- C. Entertainment and recreation
- D. Religion

IV. Visiting Tokyo

V. Economy
- A. Industry
- B. Finance
- C. Trade
- D. Transportation

VI. Government
- A. Organization
- B. Problems

VII. History

Questions

What is the *ward area*?
What is the most popular sport in Tokyo?
Why is Tokyo's government unusually complicated?
What kind of clothing do many Tokyo students wear?
What are Tokyo's two leading industries?
How large a part of Japan's population lives in Tokyo?
Why do parts of Tokyo face the danger of flooding?
What are Tokyo's main kinds of public transportation?
When was Tokyo made the capital of Japan?

Tokyo Rose. See **World War II** (Propaganda).

Tolais are a people who live in an area about 32 kilometres from Rabaul, on the island of New Britain in Papua New Guinea. The Tolais were once cannibals, but now they are among the country's most advanced and wealthy people. Their income comes mainly from selling coconuts and cocoa and from small businesses. There are about 40,000 Tolais. The Tolai area is one of the most densely populated in Papua New Guinea.

Toledo (pop. 57,769) is a Spanish city located on a high hill about 65 kilometres southwest of Madrid. The Tagus River flows in a deep ravine around the hill. The city is the capital of Toledo province. For location, see **Spain** (political map).

Toledo is a medieval city of narrow, steep, winding streets. There are many historic buildings in Toledo, and the Spanish government has declared the entire city a national monument. The architecture of Toledo shows a strong Moorish influence. Houses rise straight up, many of them without windows facing the streets. A magnificent Gothic cathedral dominates the city. Its tower rises about 90 metres. Beautiful chapels inside the cathedral contain many fine paintings and statues. The painter El Greco lived in Toledo, and his home is now a museum for some of his paintings.

Toledo has little industry, but is famous for firearms, swords, textiles, and *Toledo ware* (inlaid steel). Its founding date is unknown. Arabs destroyed the city in the 700's. Alfonso VI, king of León and Castile, seized Toledo in 1085 and made it his capital. Philip II made Madrid the capital in 1561.

Toledo (pop. 332,943; met. area pop. 614,128) is a leading industrial and transportation centre in northwestern Ohio, U.S.A. It is also a major Great Lakes port. For many years, the city was a key glass-manufacturing centre. However, several of the firms that specialized in glassmaking now make other kinds of products. Toledo also produces cars and car parts . The port of Toledo handles about 11 million metric tons of cargo annually. It ships mainly coal, iron ore, and petroleum. The port also handles huge volumes of maize, wheat, and other grain, grown in the rich agricultural region of northwestern Ohio.

Tolentino, Guillermo (1890-1976), was a great Filipino sculptor. His most famous work is the *National Heroes Monument,* also called the *Bonifacio Monument,* in Grace Park, Caloocan. The monument was designed in 1930 and features figures from the Philippine Revolution of 1896. Other works include *Oblation,* the *Four Horsemen of the Apocalypse,* and the *Saluto Romano* (Salute to Rome). Tolentino combined the classical tradition of idealization with expressive realism in his work. The French sculptor Auguste Rodin, and the painters Eugene Delacroix and Theodore Gericault, were important influences on his work.

Tolentino was born in Malolos, near Manila. He graduated from the School of Fine Arts at the University of the Philippines in 1915. He then studied in New York City and Rome, returning to Manila in 1925.

Toleration Act. See **United Kingdom, History of the** (The Glorious Revolution).

Tolkien, J. R. R. (1892-1973), an English author and scholar, wrote a popular series of novels about an imaginary people called *hobbits.* Tolkien introduced these creatures in *The Hobbit* (1937). He continued their story in three related novels called *The Lord of the Rings.* These novels are *The Fellowship of the Ring* (1954), *The Two Towers* (1954), and *The Return of the King* (1955).

Hobbits are industrious and good-natured. They live in a world called Middle-earth, along with elves, goblins, wizards, and human beings. In *The Hobbit,* Bilbo Baggins, a hobbit, discovers a ring that makes the wearer invisible, but also has the power to corrupt. The hero of *The Lord of the Rings* is Frodo Baggins, Bilbo's cousin. After many adventures, Frodo destroys the ring so that Sauron, the evil Dark Lord, cannot use it against the people of Middle-earth. Many critics have interpreted *The Lord of the Rings* as a symbolic moral or religious story about the battle between good and evil. But Tolkien insisted that he wrote the novels only as fantasies to entertain readers.

In 1917, Tolkien began to write *The Silmarillion,* a history of Middle-earth before the hobbits appeared. He worked on the book occasionally for the rest of his life but died before completing it, and his son Christopher finished the novel. It was published in 1977. A collection of previously unpublished material about Middle-earth and the legendary island of Númenor appeared in 1980 as *Unfinished Tales.*

John Ronald Reuel Tolkien was born in Bloemfontein, South Africa, of English parents. From 1925 to 1959, he taught at Oxford University in England. He specialized in medieval languages and literature and wrote several scholarly works in this field. Tolkien's hobbit stories show the influence of the medieval English, German, and Scandinavian languages and literature.

Tolman, Edward Chace (1886-1959), was an American psychologist known for his theory of how human beings and animals learn. Tolman rejected the learning theory of John B. Watson and other behavioural psychologists of the time. These psychologists maintained that learning occurs through a random trial-and-error process. Tolman argued that learning is a systematic process guided by goals and expectations. He believed that learners develop what he called *cognitive maps*—that is, mental images of the probable paths to their goals. He explained his theory in a book called *Purposive Behavior in Animals and Men* (1932).

Tolman was born in Newton, Massachusetts, U.S.A. He taught psychology at the University of California at Berkeley, California, U.S.A., from 1918 until his death.

Tolpuddle martyrs were six farm labourers from the village of Tolpuddle, in Dorset, England. They were transported to Australia in 1834 because they took part in trade union activities. They were among the first transportees convicted on political grounds. Later political transportees were pioneers of the labour movement in Australia. People throughout Britain protested strongly against the sentence of transportation. In 1836, the men received a pardon and returned to Britain.

Tolstoy, Alexei (1882-1945), Count Tolstoy, won great popularity and wealth in Russia as a writer of novels and plays. His name is also spelled *Tolstoi.* He wrote *Road to Calvary* (1921-1941), a trilogy portraying Russian life just before, during, and after the Russian civil war of 1918-1920. He also wrote *Peter I* (1929-1945), an unfinished novel about that czar. Tolstoy portrayed Czar Ivan IV in two plays called *Ivan the Terrible* (1942 and 1943).

Alexei Nikolaevich Tolstoy was born in the province of Samara. He studied engineering at the Saint Petersburg Technological Institute, but gave up this career in favour of writing. During the Revolution of 1917, Tolstoy fled from Russia, but he returned in 1922. He gave up his title of count and wrote propaganda for the Soviet Union. He was a distant relative of the Russian writer Leo Tolstoy.

Tolstoy, Leo (1828-1910), a Russian writer, ranks among the greatest novelists in world literature. Tolstoy was also an important moral and religious thinker and social reformer. His name is sometimes spelled *Tolstoi.*

Early life and works. Leo Nikolaevich Tolstoy was born at Yasnaya Polyana, his family's estate near Tula, Russia. Both of his parents died when he was young, and he was raised by relatives. Tolstoy received his primary education from foreign tutors. He entered the University of Kazan in 1844, but became bored with university instruction and did not earn a degree. He returned to Yasnaya Polyana in 1847 to manage the estate and devote himself to study. He wrote three semiautobiographical novels that reflect his formative years—*Childhood* (1852), *Boyhood* (1854), and *Youth* (1857).

As a young man, Tolstoy spent considerable time among the high society of Moscow and St. Petersburg. His diaries reveal that he became restless and dissatisfied with this life, and thus decided to volunteer for the Russian Army.

Tolstoy was a soldier during the Crimean War (1853-1856). He distinguished himself for bravery at the Battle of Sevastopol. He wrote several Sevastopol sketches for magazines in 1855, depicting war as an unglamorous bloodbath and attacking romantic ideas of war heroes. Another of Tolstoy's works based on his travels with the army was the highly praised short novel *The Cossacks* (1863). Olenin, the central character of the novel, is a refined aristocrat. He finds much to admire in the wild, free life of the Cossacks of the Caucasus region in southwestern Russia.

Tolstoy retired from military service in 1856. Between 1857 and 1861, he made two trips to western Europe, where he took a keen interest in educational methods. After returning to his estate, he opened a school for peasant children there. Tolstoy was successful as a progressive educator who believed that teaching should be adapted to the needs of each pupil. He published a journal, called *Yasnaya Polyana,* explaining his educational theories.

His masterpieces. In 1862, Tolstoy married Sonya Behrs. At first the two had a happy marriage, though it became troubled in later years. During this period, Tolstoy wrote *War and Peace* and *Anna Karenina,* his greatest works.

The epic novel *War and Peace* was published in its complete form in 1869. Like many other works of Russian realism, *War and Peace* is a family chronicle. It shows the lives of five families as they go through the universal experiences and stages of life that always concerned Tolstoy—birth, growing up, marriage, sex, childbirth, maturity, old age, and death. *War and Peace* is also a historical novel, describing the political and military events that occurred in Europe between 1805 and 1820. It focuses in particular on Napoleon's invasion of Russia in 1812. In the novel, Tolstoy rejected the "Great Man" theory of history. According to Tolstoy's theory, prominent people or heroes actually have no significant impact on the course of history.

Tolstoy's second masterpiece, *Anna Karenina,* was published in instalments from 1875 to 1877. Its plot concerns the open infidelity of a Russian princess, Anna Karenina, to her husband, Karenin. The novel examines Anna's romance with Count Vronsky. Anna and Vronsky show contempt for the disapproving opinions of the members of the high society to which they belong. The difficulties of their relationship eventually lead to Anna's suicide. But *Anna Karenina* is more than a tragic love story. The novel explores broad social, moral, and philosophical issues of Russia and its aristocracy in the 1870's. These issues include the hypocritical attitude of the upper class toward adultery and the role of religious faith in a person's life. Many of these vital issues are raised through the thoughts and actions of Konstantin Levin, the novel's second most important figure. Through Levin, Tolstoy expresses many of his own views.

Leo Tolstoy

His conversion. During the years that Tolstoy was writing *Anna Karenina,* he became obsessed with the questions that had always been in the forefront of his mind concerning the meaning and purpose of life. Tolstoy described his agonizing moral self-examination and his quest for life's meaning in the essay "My Confession" (1882).

Tolstoy changed dramatically as a result of his spiritual crisis. Rejecting the authority of the Russian Orthodox Church, he developed his own version of Christianity, which he later detailed in the essay "The Kingdom of God Is Within You" (1894). Tolstoy believed that people are able to know and affirm the good in themselves if they engage in self-examination and willingly reform themselves. Tolstoy also believed that any use of violence or force is harmful, and that force should be opposed nonviolently. Tolstoy objected to all forms of force, including that represented by organized government and religion, private property, and the bonds of oaths.

Tolstoy produced no fiction between 1878 and 1885, writing instead on his religious beliefs and social themes. In his zeal to live in conformity with his religion, he gave up his property and sex life. He left his estate to his family, and his wife obtained the copyrights to all his works written before 1881. Tolstoy dressed as a peasant and often worked in the fields. He tried to be as self-sufficient as possible. Tolstoy's great fame as a novelist sparked a public interest in his religion that spread quickly. People made pilgrimages from all over the world to visit him. His authority was so great that the Russian Orthodox Church excommunicated him in 1901 in an effort to minimize his influence.

In his essay "What Is Art?" (1898), Tolstoy denounced all of the works he created before his conversion. The essay advances the idea that art should help to morally instruct and improve people. Tolstoy also wrote that art should communicate its ideas to even the simplest people. By these standards, Tolstoy judged most of his earlier works as "aristocratic art" written for vain purposes and not intelligible to the common person.

Later works. Tolstoy returned to writing fiction with the tale "The Death of Ivan Ilyich" (1886). In the story, Ivan Ilyich is the victim of a fatal disease. While he is dying, he sees the emptiness of his life, and he can only accept the inevitability of death. Tolstoy also wrote several plays. His best-known drama, *The Power of Darkness* (1888), is a tragedy about a peasant whose adulterous passion drives him to commit terrible crimes. Tolstoy was interested in the stage for its potential to reach a wide-ranging audience, but his dramas seldom attained the heights of his novels and short stories.

The major novel of Tolstoy's later period is *Resurrection* (1899), the story of the spiritual reformation of a young nobleman. The stories "The Devil" (1889) and "The Kreutzer Sonata" (1891) focus on love, jealousy, and the destructive component of the sex drive. The novel *Hadji Murad,* published after Tolstoy's death, tells the tale of a tribal leader in the Caucasus Mountains. In this story, Tolstoy again shows himself as the masterful psychologist and great literary craftsman of his earlier years.

While important and influential as a moralist, Tolstoy was, first and foremost, a creative writer. Tolstoy's religious and moralistic works are flat when compared to the beauty of his greatest works of fiction.

Toluene is a colourless liquid related to benzene. Toluene is also called *methylbenzene.* It belongs to a group of compounds called *aromatic hydrocarbons.* Its chemical formula is $C_6H_5CH_3$. A molecule of toluene has its six carbon atoms arranged in a ring with five hydrogen atoms and a *methyl* (CH_3) group attached.

Manufacturers make toluene by treating petroleum or distilling coal tar. Chemists use toluene as a raw material to produce other chemicals. For example, they sometimes make benzoic acid from it. Benzoic acid is used as a preservative for foods, beverages, and cosmetics. An antiseptic known as chloramine-T is also made from toluene. Makers of explosives use toluene to make trinitrotoluene, commonly called TNT. Paint manufacturers use toluene as a lacquer solvent. Toluene is also used in the manufacture of many dyes and perfumes. Health regulations in some countries require manufacturers to limit the amount of toluene in the air breathed by workers. Excessive exposure to toluene can damage the skin, the eyes, and the central nervous system.

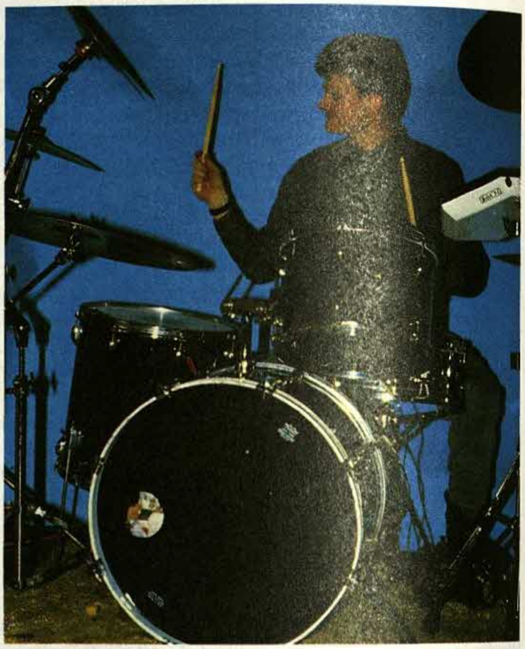
See also **Benzene; TNT.**

Tom Sawyer. See Twain, Mark.

Tom Thumb. See Stratton, Charles Sherwood.

Tom Thumb was the name of the first American-built steam locomotive to be operated on a common-carrier railway. Peter Cooper designed and built it in 1830. It operated on the Baltimore and Ohio Railroad in Baltimore, Maryland, U.S.A., in the summer of 1830. It pulled one of the first passenger trains. See also **Railway** (History [The railway age begins]).

Tom-tom is a musical instrument that belongs to the drum family. Most tom-toms consist of a cylinder with a thin sheet of plastic or calfskin called a *head* stretched across the top, bottom, or both. The tom-tom measures from about 15 to 45 centimetres in diameter and stands from about 15 to 50 centimetres high. It has a dull, hollow sound and may be tuned with a *drum key,* which adjusts the tightness of the heads. Musicians play the tom-tom with felt mallets, drumsticks, or with their hands.



The tom-tom is an important rhythm instrument, especially in rock and jazz bands. This drummer is playing a bass tom-tom, *left.* Another tom-tom is mounted above the large bass drum.

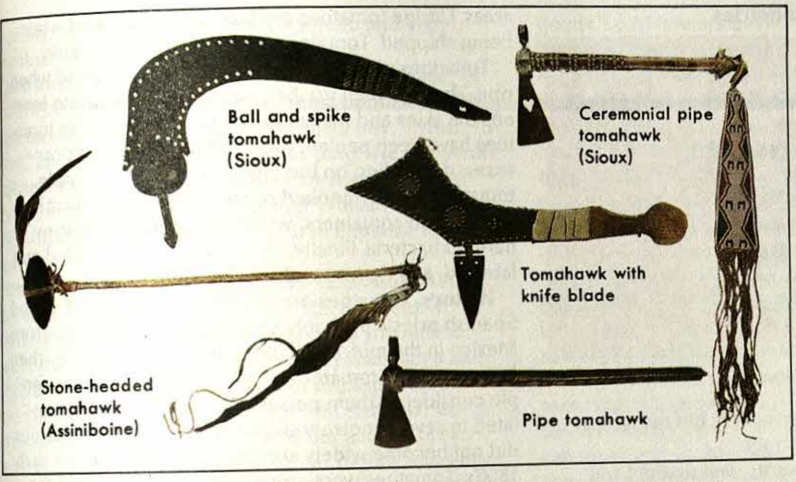
Tom-toms date back to ancient times. The earliest tom-toms consisted of an animal skin stretched across the opening of a hollowed log. Today, tom-toms form part of the drum set used in many jazz and dance bands. Sets of four one-headed tom-toms are used in concert bands, orchestras, and percussion groups.

Tomahawk was a small axe that the Indians of North America used as a tool and a weapon. Most tomahawks measured less than 45 centimetres long and were light enough to be used with one hand. Early tomahawks consisted of a *head* (top part) made of stone or bone mounted on a wooden handle. Some tomahawks ended in a ball or knob instead of a flat blade. After Europeans arrived in America, the Indians traded with them for iron tomahawk heads.

The Indians used tomahawks to chop wood, to drive stakes into the ground, and for many other purposes. In battle, warriors used their tomahawks as clubs or threw them at their enemies. Tomahawks also served as hunting weapons.

The Indians used a *pipe tomahawk* in religious ceremonies. This special kind of tomahawk had a pipe bowl on the head and a hollow handle, and it could be smoked as a ceremonial pipe. The Indians decorated their pipe tomahawks with feathers or with dyed porcupine quills.

Some people think the expression *bury the hatchet* came from an Indian custom of burying a tomahawk to


Ball and spike tomahawk (Sioux)
Ceremonial pipe tomahawk (Sioux)
Tomahawk with knife blade
Stone-headed tomahawk (Assiniboine)
Pipe tomahawk

Some kinds of tomahawks

The Indians of North America used many different types of tomahawks. Some ended in a ball or knob, and some in a flat blade. Early tomahawks had stone or bone heads, and later ones were made of iron. Pipe tomahawks had a pipe bowl on the head and a hollow handle, so that they could be smoked.

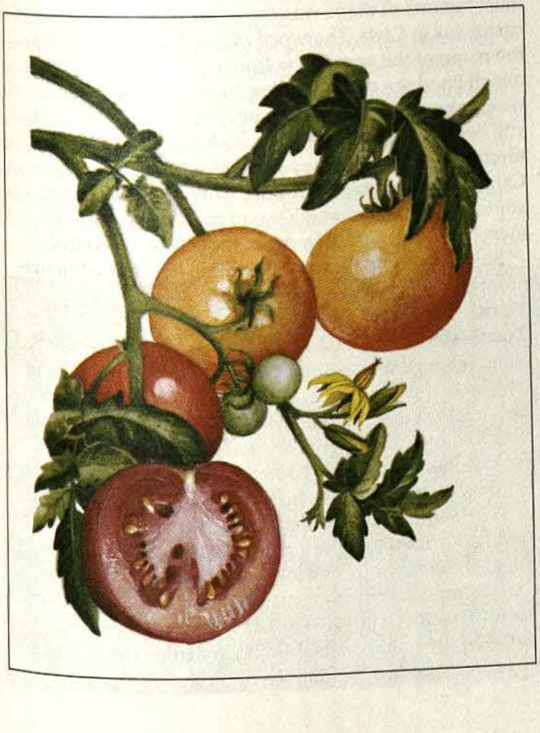
pledge peace. However, many scholars doubt that the Indians ever had such a custom.

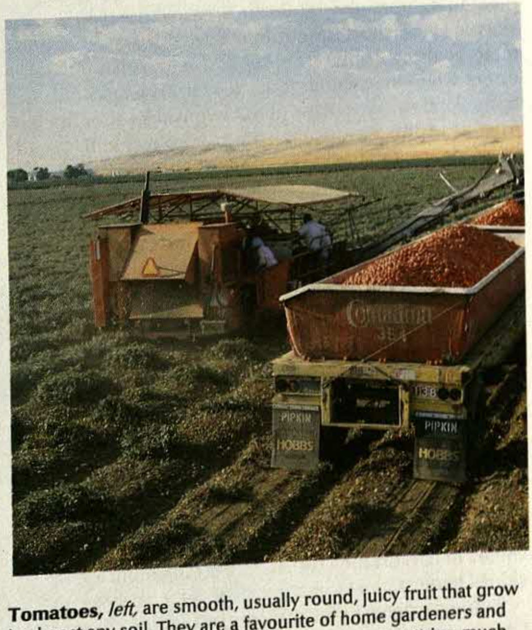
Tomato is a plant grown for its smooth, usually round, juicy fruit. The word *tomato* refers both to the fruit and to the entire plant. The fruit has a slightly acid taste. There are more than 4,000 varieties of tomatoes.

Botanists classify tomatoes as fruit. Horticulturists, however, classify them as vegetables. Most other people consider tomatoes vegetables because fresh tomatoes are used in much the same way as lettuce, onions, cauliflower, and many other vegetables. Fresh tomatoes are eaten raw or cooked and are generally served in salads and other dishes. Much of the tomato crop grown in industrial countries is processed for use in making a variety of food products. These products include tomato ketchup, tomato juice, tomato soup, tomato paste, tomato sauce, and canned whole tomatoes. Tomatoes are an important source of vitamins A and C and of certain minerals.

About 72 million metric tons of tomatoes are grown throughout the world annually. The United States produces more tomatoes than any other nation. Turkey, China, Italy, and Egypt are also major producers of tomatoes. Growers in the United States raise a commercial tomato crop of about 10 million metric tons yearly. About three-quarters of the crop comes from California, but tomatoes are grown in almost every area of the United States.

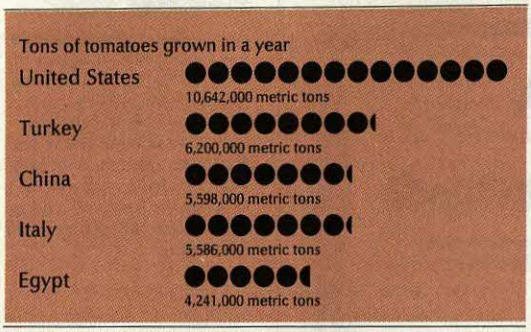
The tomato plant has a strong smell and has small hairs on its stems. It spreads out while growing and produces clusters of small yellow flowers. The flowers develop into ripe tomatoes in 40 to 75 days, depending on





Tomatoes, *left,* are smooth, usually round, juicy fruit that grow in almost any soil. They are a favourite of home gardeners and are also widely grown commercially. In some countries, much of the commercial crop is harvested by machine, *above.*

Leading tomato-growing countries



Figures are for a three-year average, 1990-1992.
Source: Food and Agriculture Organization of the United Nations.

the variety. Tomatoes are green at first, but most turn red, orange, or yellow as they ripen.

Tomatoes thrive in fertile, warm, well-drained soil and in locations that receive at least six hours of direct sunlight each day. Tomatoes are a favourite of home gardeners, because they can be grown in nearly any kind of soil. In addition, a large crop requires relatively little space. Many varieties produce 4.5 to 7 kilograms of fruit per plant. The *Ponderosa* variety may produce tomatoes that weigh more than 1.4 kilograms each.

Researchers and growers have bred tomatoes to increase the number of fruit per plant and to improve their quality and other features. For example, the leading variety of tomato grown in California, U.S.A., *VF 145,* was developed especially for harvesting by machines. Other popular commonly grown types include cherry tomatoes and beefsteak tomatoes.

Growing, harvesting, and processing. Tomato seeds require 75 to 85 days to develop into mature plants with ripe fruit. In areas that have a long growing season, the seeds can be planted outdoors. They are planted indoors under glass in areas where the growing season is too short for outdoor development. Young tomato plants obtained from seeds are transplanted outdoors when the seedlings are four to six weeks old. The transplanting takes place about two weeks after the last frost of spring, because tomato plants can be damaged by cold temperatures.

In gardens and greenhouses, most tomato plants are supported with stakes or trellises to keep them from spreading on the ground. Such supports allow the plants to be placed closer together, thus increasing the yield of each unit of land. The supports also help produce a better quality fruit and prevent a disease called *fruit rot* by keeping the fruit off moist ground.

The most common diseases of the tomato are *bacterial wilt, fusarium wilt,* and *verticillium wilt* (see **Wilt**). Several kinds of insects and worms also attack tomatoes. Plant breeders have developed varieties of the plants that resist some diseases and pests. Many growers also use chemicals to fight the enemies of tomatoes.

Most tomatoes grown to be eaten fresh are picked by hand, but an increasing number of growers use machines to harvest the crop. In industrial countries, machines harvest most tomatoes grown for processing.

Home gardeners pick tomatoes when they are ripe. Commercially grown tomatoes are picked before they ripen. Then they are shipped to warehouses in market areas. Unripe tomatoes are less easily damaged while being shipped. Tomatoes ripen in the warehouses.

Tomatoes grown for processing are harvested when ripe. They are then washed and scalded. Scalding loosens the skins and makes peeling easier. After the tomatoes have been peeled, they undergo different processes, depending on the final product. For example, tomatoes may be cooked or strained. The product is packed into containers, which are heated to destroy harmful bacteria. Finally, the containers are cooled and labelled, and then stored for shipping.

History. Tomatoes originated in South America, and Spanish priests probably brought them to Europe from Mexico in the mid-1500's. People in Spain and Italy then began to grow tomatoes as food. However, many people considered them poisonous because they are related to several poisonous plants. As a result, tomatoes did not become widely accepted as food until the early 1800's. Tomatoes were sometimes called *love apples,* perhaps because of a superstition that eating them made people fall in love.

Scientific classification. The tomato belongs to the nightshade family, Solanaceae. Its scientific name is *Lycopersicon esculentum.*

Tomb is any chamber in which the dead are buried. Some tombs are cut out of rocks, and others are built above ground. Ancient peoples used tombs to keep the bodies of the dead safe. The Egyptians believed the departed person's spirit visited the burial place. They built the Pyramids, the world's greatest tombs, for their kings (see **Pyramids; Valley of the Kings**). Many ancient tombs contained personal possessions. Scholars have learned much about earlier cultures from such tombs.

The Jews cut tombs out of rock. Christ was said to have been placed in a new rock tomb belonging to Joseph of Arimathea. Most Greek tombs were simple, but those in the colonies of Asia Minor were elaborate. The most famous of these was the tomb of Mausolus at Halicarnassus in Caria. The word *mausoleum* comes from the name of this tomb. The Romans built stately tombs which lined the roads leading to the city, because burial within the city was not allowed. Ruins of Roman tombs still line the Appian Way. The early Christians built tombs in underground rooms called *catacombs* (see **Catacombs**). Islamic tombs are often large buildings, sometimes with a dome. One of the most famous of these is the Taj Mahal in Agra, India (see **Taj Mahal**).

See also **Crypt; Funeral customs; Megalithic monuments; Sarcophagus.**

Tombouctou. See **Timbuktu.**

Tombstone (pop. 1,632) is a town in southeastern Arizona, U.S.A., that was the centre of a rich silver-mining district in the late 1800's. It was named by its founder, prospector Ed Schieffelin. His friends feared he would be killed by Indians, and warned him he would find a tombstone, not a mine. Today, Tombstone attracts many tourists to its museums, historic sites, and mine tours.

Tombstone was founded in 1879. By 1882, its population had grown to an estimated 5,500 because of the silver-mining boom. Lawlessness was widespread in Tombstone, and the famous gunfight at the O.K. Corral took place there in 1881. In 1883, underground water flooded the mine shafts. Mining activities slowed, and practically ended by 1893. The population decreased steadily. But residents promoted tourism and kept Tombstone alive.

Tomkins, Thomas (1572-1656), was a composer of madrigals and church music. His most popular madrigals include "Weep no more thou sorry boy," "Music divine," and "The fauns and Satyrs tripping." He also wrote instrumental music. Tomkins was born at St. David's, Dyfed, in Wales, and was a pupil of William Byrd. He was organist of Worcester Cathedral, England, for 50 years.

Tomlin, Bradley Walker (1899-1953), was an American abstract expressionist painter. His best-known works contain strong lines arranged in a rhythmical order that suggest hieroglyphics. They maintain a balance between carefully structured, overlapping forms and such random elements as curving symbols, letters, and numerals. Tomlin's sense of order and his preference for harmonious colours set him slightly apart from most other abstract expressionists. His works are more lyrical and restrained than those of other artists in the movement.

Tomlin was born in Syracuse, New York. In 1921, he moved to New York City, where he earned a living for a time designing magazine covers. From 1925 to the late 1930's, he painted in a moderate realistic style. From 1939 to about 1944, he concentrated on cubistic blends of still-life elements and abstract forms. This style led to the simplification and abstraction of Tomlin's later works.

Ton is the name of three different units used to measure weight and capacity. The units are the *long ton, short ton,* and *metric ton.* The long and short tons are units most often used in the United States, but the metric ton is used by nearly all other countries. The long ton equals 1,016 kilograms, the short ton equals 907 kilograms, and the metric ton equals 1,000 kilograms.

See also **Measurement** (Measuring weight); **Metric system; Weights and measures.**

Tonbridge and Malling (pop. 99,100) is a local government district in Kent, England. The River Medway flows through the district, which is a residential area for many London-based workers. Its chief towns are Aylesford, East Malling, Hadlow, Hildenborough, Tonbridge, West Malling (the administrative centre), and Wrotham. Industries include all types of engineering and the manufacture of chemicals, paper products, and sheepskin goods. Local farmers grow fruit, vegetables, and hops.

Tone, in music, is a word that has several meanings. Musicians in most English-speaking countries use the word *tone* to mean the quality of a musical sound or melody. A tune played on an oboe sounds very different from the same tune played on a violin or flute. This is because all three instruments have different tones or tone qualities. Tone in this sense is often called *timbre.*

American musicians call any musical sound produced on a musical instrument a *tone.* Musicians in Britain and other countries usually refer to this as a *note.* The seven different notes of an octave scale are distinguished by letters of the alphabet. A tone is also a specific drop or rise in pitch between one note and another in a scale or melody. The interval between the notes C and D is a tone. This is also called a *whole tone* or *full tone.* The interval between E and F is a *half tone* or *semitone.* American musicians usually refer to these intervals as a *whole step* and a *half step,* respectively.

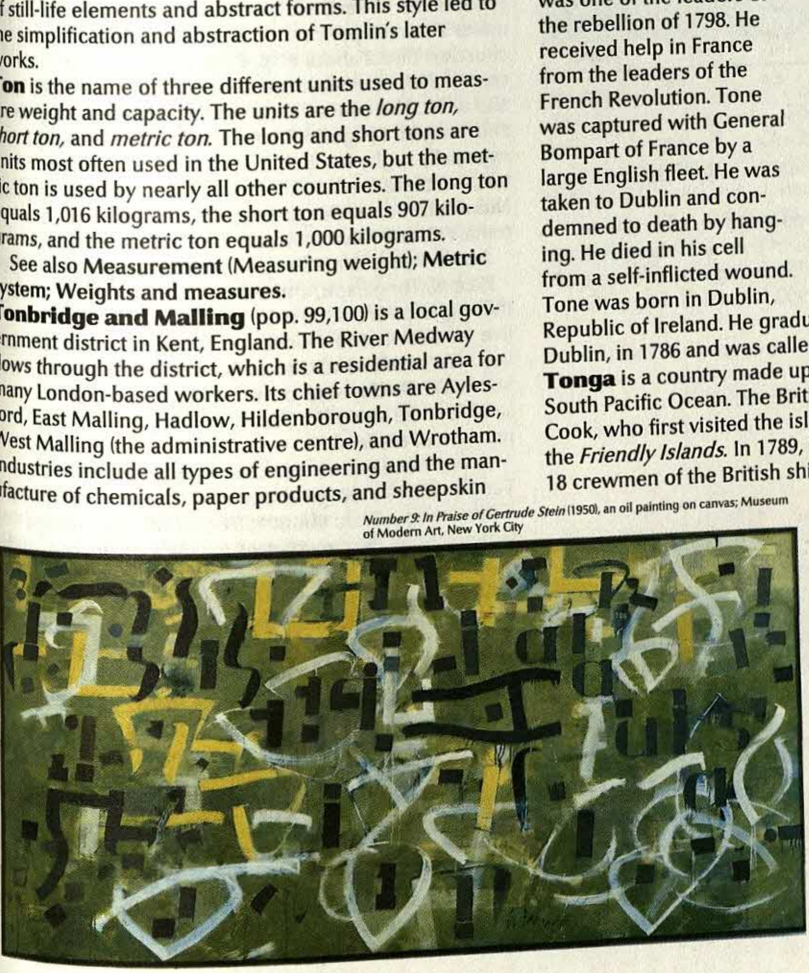
See also **Harmonics; Music** (Notes; Musical notation); **Piano** (The strings); **Sonometer; Sound** (Sound quality).

Tone, Theobald Wolfe (1763-1798), was an Irish soldier and patriot. He was one of the founders of the United Irishmen, a revolutionary organization (see **United Irishmen**). Tone was one of the leaders of the rebellion of 1798. He received help in France from the leaders of the French Revolution. Tone was captured with General Bompart of France by a large English fleet. He was taken to Dublin and condemned to death by hanging. He died in his cell from a self-inflicted wound. Tone was born in Dublin, Republic of Ireland. He graduated from Trinity College, Dublin, in 1786 and was called to the Bar in 1789.

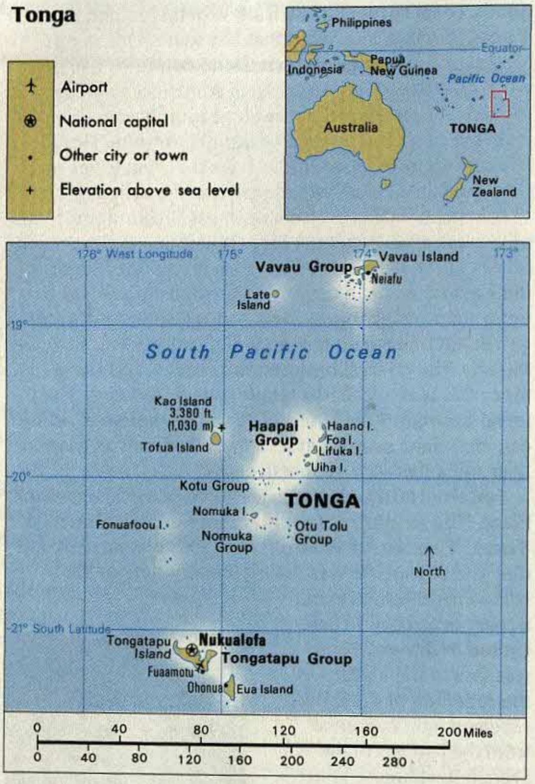
Theobald Wolfe Tone

Tonga is a country made up of about 150 islands in the South Pacific Ocean. The British explorer Captain James Cook, who first visited the islands in 1773, called them the *Friendly Islands.* In 1789, Captain William Bligh and 18 crewmen of the British ship *Bounty* floated

Number 9: In Praise of Gertrude Stein (1950), an oil painting on canvas; Museum of Modern Art, New York City



A Tomlin painting shows repeated rhythmic lines and muted colours that are typical of his later style. Tomlin became a leading member of the movement in American painting called *abstract expressionism.*



through the islands after being cast adrift in a small boat by mutineers.

Tonga is the only remaining kingdom of Polynesia, one of the three main groups of the Pacific Islands. It became independent in 1970 after being a protectorate of the United Kingdom since 1900. It is a member of the Commonwealth of Nations.

Most of Tonga's people grow crops. Over half the people live on Tongatapu, the largest island. Nukualofa, Tonga's capital, chief port, and commercial centre, lies on Tongatapu. Nukualofa has a population of about 18,000.

Facts in brief about Tonga

Capital: Nukualofa.
Official languages: English and Tongan.
Official name: Kingdom of Tonga.
Area: 747 km².
Elevation: *Highest*—Kao, an extinct volcano in the Haapai group, 1,030 m above sea level. *Lowest*—sea level, along the coasts.
Population: *Estimated 1996 population*—100,000; density, 126 people per km²; distribution, 69 per cent rural, 31 per cent urban. *1986 census*—94,649. *Estimated 2001 population*—104,000.
Chief products: bananas, copra, sweet potatoes, tapioca.
National anthem: "'E 'Otua Mafimafi" ("O God Almighty").
Flag: The flag has a red field and a white canton. A red cross in the canton symbolizes the Christian faith of the Tongans. Adopted in 1866. See **Flag** (picture: Flags of Asia and the Pacific).
Money: *Currency unit*—pa'anga. One pa'anga = 100 seniti.

Government. Tonga is a constitutional monarchy. The king appoints a prime minister and a Cabinet to assist him. The Cabinet consists of the prime minister and six other members. The Legislative Assembly is composed of the Cabinet, seven nobles elected by Tonga's hereditary nobility, and seven commoners elected by the people. Elections take place every three years. Tongans who are at least 21 years old and can read and write may vote in elections.

The Legislative Assembly meets for two or three months a year. When the assembly is not in session, the privy council has the power to make laws. The privy council, headed by the king, consists of the prime minister, the Cabinet, and the governors of two major island groups—Haapai and Vavau. The Legislative Assembly may change laws passed by the privy council. The king appoints the governors of Haapai and Vavau.

People. Almost all the people of Tonga are Polynesians and are Christians. Tonga's Constitution prohibits work or recreation on Sunday, and the people follow this law strictly. Most Tongans live in small villages and grow crops. The people also fish for such seafood as shark and tuna. Most of the islands have no running water, and many have no electricity.

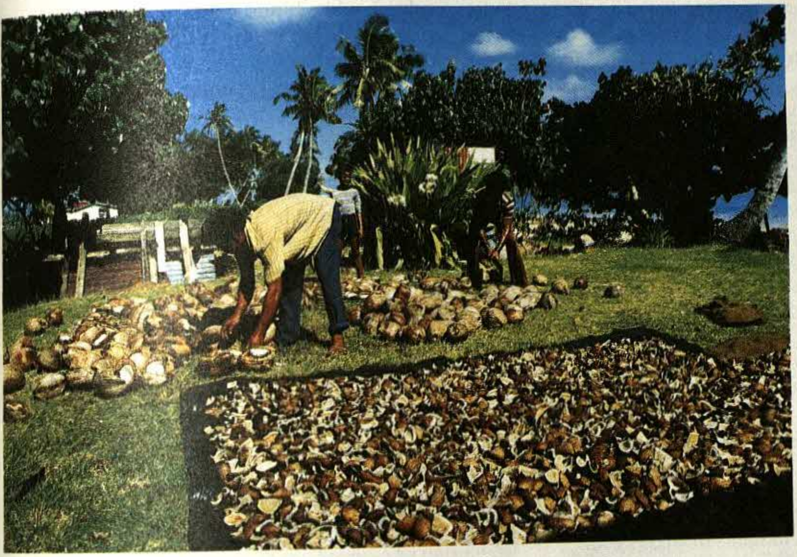
The law requires all Tongan children from 6 to 14 years old to go to school. Tonga has about 125 primary schools and 45 secondary schools. The government operates about 60 per cent of the schools, and the churches direct about 40 per cent. More than 90 per cent of the population aged 15 and over are able to read and write. The country's official languages are English and Tongan. Tongan schoolchildren enjoy many sports, especially rugby football. The country has no universities, but there is a teacher-training college in the capital, Nukualofa. Some Tongans attend universities in Australia, Fiji, and New Zealand.

Land. Tonga is made up of three main island groups Haapai, Tongatapu, and Vavau. Most of the islands in these groups are coral reefs. Most of Tonga's people live on these islands. A chain of higher, volcanic islands lies west of the coral islands. Some of the volcanoes are active. Fertile clay soils cover most of Tonga. Strips of sandy soil lie along the coasts. Forests cover about 14 per cent of the land.

Tonga has a warm, wet climate with high humidity. Temperatures average about 26 °C. The average annual rainfall ranges from about 180 centimetres on Tongatapu to about 250 centimetres on some northern islands. Most rain falls from December to March. Cyclones sometimes hit Tonga.

Economy. Fertile soils and a warm climate have made agriculture the basis of the Tongan economy. About three-quarters of the workers are farmers. The government owns all the land. Every male who is 16 or over is entitled to a plot of land, which he rents from the government. The government has helped establish small-scale manufacturing, especially in Nukualofa. Tourism is also important to the economy.

Tonga's crops include bananas, breadfruit, sweet potatoes, tapioca, and yams. The chief exports are fruit, vegetables, and *copra* (dried coconut). Most exports go to New Zealand. Australia and New Zealand supply most of the imports, including flour, meat, petroleum, sugar, textiles, and tobacco.



Tongan farmers shell coconuts to obtain copra, one of the nation's chief exports. Copra, the dried meat of the coconut, is used in making soap, margarine, and other products.

Tonga has over 320 kilometres of roads, mostly on Tongatapu. Shipping services operate among the many islands. Government-owned shipping services connect Tonga with Australia, New Zealand, Hawaii, and other places in the Pacific. Neiafu and Nukualofa are Tonga's chief ports. The most important airport operates at Fuaamotu on Tongatapu. Tonga has no railways. The government publishes a weekly newspaper in both Tongan and English. The government operates the country's one radio station.

History. The first people to settle in Tonga were Polynesians who probably came from Samoa. Although much of Tonga's early history is based on myths, records of Tongan rulers go back to the A.D. 900's. The early rulers held the hereditary title of *Tu'i Tonga.* The people believed the Tu'i Tonga were sacred representatives of the Tongan gods. About 1470, the ruling Tu'i Tonga gave some governing powers to a nonsacred leader. Over the years, the Tu'i Tonga became only a figurehead. By 1865, after the death of the last Tu'i Tonga, the nonsacred king held all the ruling power.

Two Dutch navigators, Willem Schouten and Jacob le Maire, became the first Europeans to visit Tonga. They landed on some of the northern islands in 1616. In 1643, Abel Tasman, a Dutch sea captain, visited Tongatapu and other southern islands.

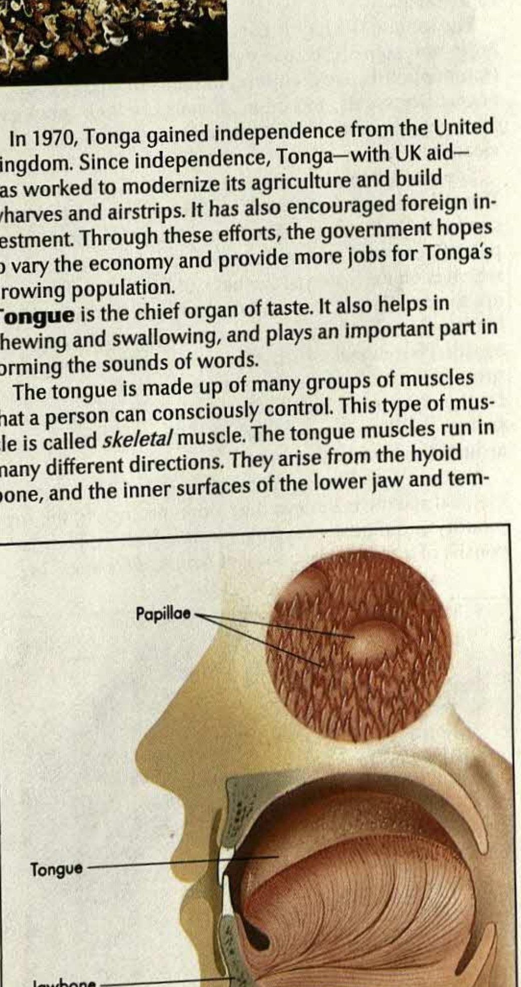
British Methodist missionaries settled in Tonga during the early 1800's and converted most of the people to Christianity. But civil war spread throughout Tonga. One of the most powerful chiefs, Taufa'ahau, united the islands in 1845. He was crowned King George Tupou I, the first monarch of Tonga. Tupou I developed legal codes that became the basis of the Tongan Constitution, which was adopted in 1875.

After Tupou I died in 1893, his great-grandson, George Tupou II, took the throne. Tonga became a protectorate of the United Kingdom in 1900. Queen Salote succeeded Tupou II in 1918 and ruled until her death in 1965. Salote worked to improve education and health in Tonga. Her son became King Taufa'ahau Toupou IV in 1967.

In 1970, Tonga gained independence from the United Kingdom. Since independence, Tonga—with UK aid—has worked to modernize its agriculture and build wharves and airstrips. It has also encouraged foreign investment. Through these efforts, the government hopes to vary the economy and provide more jobs for Tonga's growing population.

Tongue is the chief organ of taste. It also helps in chewing and swallowing, and plays an important part in forming the sounds of words.

The tongue is made up of many groups of muscles that a person can consciously control. This type of muscle is called *skeletal* muscle. The tongue muscles run in many different directions. They arise from the hyoid bone, and the inner surfaces of the lower jaw and tem-



The tongue consists of bundles of muscles that run in several directions. It is covered by a mucous membrane, and its upper surface has round and cone-shaped projections called *papillae.*

poral bones. As a result, a person can move the front part of the tongue many different ways. The tongue can move food about, push it between the teeth, and roll it into small masses. It helps clean the mouth by removing food from between the cheeks and teeth. In swallowing, the tongue pushes the food back into the *pharynx* (throat). In doing this, the tongue presses against the *palate* (roof of the mouth) and also spreads against the sides of the mouth. This action prevents the food from moving in any direction except back into the pharynx.

The tongue is covered with a mucous membrane. The undersurface of the tongue is smooth. But many *papillae* (small projections) give the tongue a rough surface on the top.

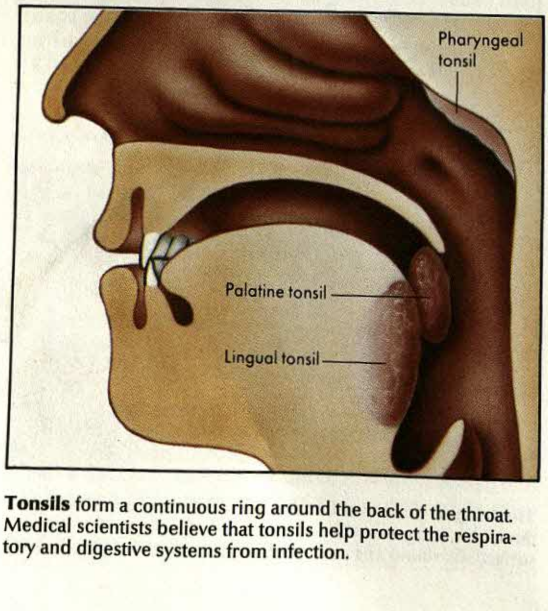
Four types of taste buds, found in the papillae, enable us to distinguish between sweet, sour, salty, and bitter tastes (see **Taste**). The tip of the tongue is more sensitive to the feeling of touch than any other part of the body (see **Touch**).

The tongue is a highly useful organ to many animals. Frogs and some birds use their tongues to catch insects. Hummingbirds use their long tongues to lap up plant nectar. Dogs, cats, and other animals use their tongues for many purposes, such as to lap up water or milk, to clean their fur, or to express affection.

See also **Chameleon; Snake** (picture); **Toad.**

Tonsil is any one of several masses of specialized tissue found in the throat. The term commonly refers to a pair of deep pink, almond-shaped structures, one of which is on each side of the back of the throat. These are the *palatine,* or *faucial,* tonsils. There are two other kinds of tonsils—the *pharyngeal* tonsils and the *lingual* tonsils. Pharyngeal tonsils, commonly called *adenoids,* grow in the back of the throat near the nasal passage. Lingual tonsils are found at the back of the tongue. Together, the three types of tonsils form a continuous ring around the back of the throat.

No one really knows the purpose of tonsils, but many medical scientists believe they aid in protecting the respiratory and digestive systems from infection. Tonsils consist of a type of tissue called *lymphoid tissue.* This tissue produces white blood cells, known as *lymphocytes,* that help fight infection. For example, lymphocytes release antibodies that destroy invading bacteria and viruses or make them harmless (see **Lymphatic system** [Lymphoid tissue]). In addition, the surface of the palatine tonsils has many deep pits, called *crypts,* in which bacteria and food particles collect. Each lingual tonsil has a crypt, but the pharyngeal tonsils have none.



Tonsils form a continuous ring around the back of the throat. Medical scientists believe that tonsils help protect the respiratory and digestive systems from infection.

Sometimes the palatine or pharyngeal tonsils become badly inflamed and must be removed by a surgical operation. As children grow older, their tonsils tend to decrease in size.

See also **Tonsillitis; Adenoids.**

Tonsillitis is a painful disease resulting from inflamed tonsils. It is caused by bacteria or viruses that infect one or both of the palatine tonsils. Most attacks of tonsillitis occur in persons between the ages of 10 and 40. An attack begins with swelling and pain in the throat and difficulty in swallowing. Fever, headache, backache, stiff neck, and nausea occur in severe cases. Sometimes an *abscess* (collection of pus) forms next to the tonsil in the throat.

Doctors generally recommend bed rest, aspirin, and saltwater gargles to relieve the symptoms of tonsillitis. If the infection is bacterial, doctors can cure it with antibiotics. Antibiotics are not effective against viral tonsillitis. Some people suffer from long-lasting or repeated attacks of tonsillitis. Doctors may recommend that the tonsils be removed in such cases. The operation to remove the tonsils is called a *tonsillectomy.*

Tonti, Henri de, also spelled *Tonty* (1650-1704), was a French explorer who helped open the midwestern part of what is now the United States. He was the companion of Sieur de la Salle in 1682, when they travelled all the way down the Mississippi River to its mouth.

Tonti, the son of Italian parents, was probably born in Paris. In 1678, he went to Canada with La Salle, and two years later they travelled together into what is now Illinois, U.S.A. Tonti took command of Fort Crèvecoeur, near the present city of Peoria, Illinois. He soon retraced his route toward Canada and met La Salle at Mackinac Island in the spring of 1681.

After exploring the Mississippi Valley, Tonti took charge of Fort St. Louis, a stronghold built at Starved Rock, Illinois. This was one of the earliest white settlements in what was to become the United States. Until 1702, Tonti was the leader of the Illinois Indians. Then he joined the French-Canadian explorer Sieur d'Iberville (Pierre le Moyne) in Louisiana, U.S.A.

See also **Iberville, Sieur d'; La Salle, Sieur de.**

Tool is any instrument that a worker uses to do work. Tools that do their tasks on a machine are called *machine tools* (see **Machine tool**). Small *power-driven* tools are similar to both hand tools and machine tools. The two main kinds of tools are *woodworking tools* and *metalworking tools.*

Woodworking tools. The tools of the carpenter and cabinet-maker include such measuring tools as the *rule,* for measuring lengths; the *square* and *protractor,* for measuring angles; *compasses,* for marking circles and arcs; and *carpenter's levels* and *plumb lines,* for ensuring that carpentry work will be straight and true. *Vices* and *clamps* hold material in place while it is being shaped.

Shaping tools include *saws, chisels, planes, files,* and *boring bits.* Woodworkers also use *hammers, hatchets, screwdrivers,* and *pliers.* See **Woodworking.**

Metalworking tools. The work of the machinist and toolmaker ordinarily requires much greater precision than that of the woodworker. For this reason, measuring tools for metalworking must be extremely accurate. Many *micrometers* and *callipers* can measure distances as small as 0.0025 millimetre. The *hacksaw* used for cutting metal is much thinner and harder than the woodworking saw. Machinists use *taps* and *dies* to cut threads in machine parts. In addition, machinists use *wrenches* for repair work and in assembling machinery. Most machining operations on metal parts are done by machine tools such as lathes, milling machines, shapers, and grinders.

History of tools. Prehistoric people learned that rocks and sticks of certain shapes could help them do things they could not do with their bare hands. They later improved the natural stones they used. They shaped them into knives, hatchets, and hammers, and attached wooden handles to them. Stone-Age people developed a drill for drilling soft stone and wood. Bronze-Age people developed new tools, such as tongs for holding hot objects. Agricultural civilizations later developed new tools such as the hoe and the simple plough. See **Prehistoric people.**

After people learned to work iron and steel, they developed newer and more improved tools. Tools became stronger, sharper, and more durable. The development of steam engines, petrol engines, and electric motors made it possible to replace hand tools with machine tools. Today, much work once done by hand is done by small, power-driven hand tools.

Related articles in ***World Book*** include:

Agriculture
Axe
Die and diemaking
Drill
Forging
Hammer
Indian, American
Knife
Level
Machine tool
Plumb line
Pneumatic tool
Saw
Steam hammer

Toolmaking chiefly involves the making of precision devices and parts for power-driven machines used to shape metal. Such devices and parts are called *machine tools.* Toolmakers also produce a number of special tools and measuring instruments. Toolmaking is one of the most important and highly skilled crafts in the manufacturing industry.

The main products of toolmaking include *fixtures, jigs,* and *dies* for machine tools. Fixtures hold a *workpiece* (the metal being worked) in place while a manufacturing process, such as boring, cutting, or drilling, is performed on it. Jigs both hold a workpiece in place and guide a machine's cutting tool. Dies are used to mould, punch, bend, and cut out a workpiece. They range in size from huge blocks of steel for shaping car bodies to tiny precision devices for making watch gears. See **Die and diemaking.**

Toolmakers not only help produce machine tools but also use a variety of them in their work. For example, they use *lathes* to cut metal into round or cylindrical shapes, *milling machines* to cut flat surfaces, *grinding machines* to smooth metal, and *boring machines* to bore holes in metal. They also use a number of hand tools, including handheld drills and grinding machines.

Toolmakers, sometimes called *tool and diemakers,* must complete a training programme that lasts several years and combines practical toolmaking experience with classroom learning. Training programmes enable toolmaking students to learn about the machines, processes, and materials involved in their work. For example, they learn to set up and operate many types of machines, ranging from power saws to sophisticated computer-controlled machines. Toolmaking students study mechanical drawing and geometry, and they learn to use micrometers and other precision measuring instruments. They also receive instruction concerning the properties of metals.

See also **Cast and casting; Machine tool; Tool.**

Toomer, Jean (1894-1967), was a black American writer. He is best known for *Cane* (1923), a book of poems, short stories, and a novelette about black people in the North and the South of the United States. In *Cane,* he describes people frustrated by their conflicts with social customs and by psychological conflicts within themselves. The work is noted for its poetic and sensitive descriptions. *Cane* established Toomer as a leading American writer of the 1920's. It inspired authors of the Harlem Renaissance, an important period in black literary history.

Most of Toomer's writings after *Cane* examine philosophical and psychological problems he saw in Americans. He wrote *Essentials* (1931), a collection of thoughts on these problems. Toomer also wrote book reviews, essays, poems, short stories, and a novelette. Some of them were collected in *The Wayward and the Seeking,* published in 1980, 13 years after Toomer's death.

Toomer was born in Washington, D.C. His full name was Nathan Eugene Toomer.

See also **American literature** (The Harlem Renaissance).

Tooth. See **Teeth.**

Tooth shell. See **Mollusc** (Tooth shells; picture); **Indian, American** (Money; picture).

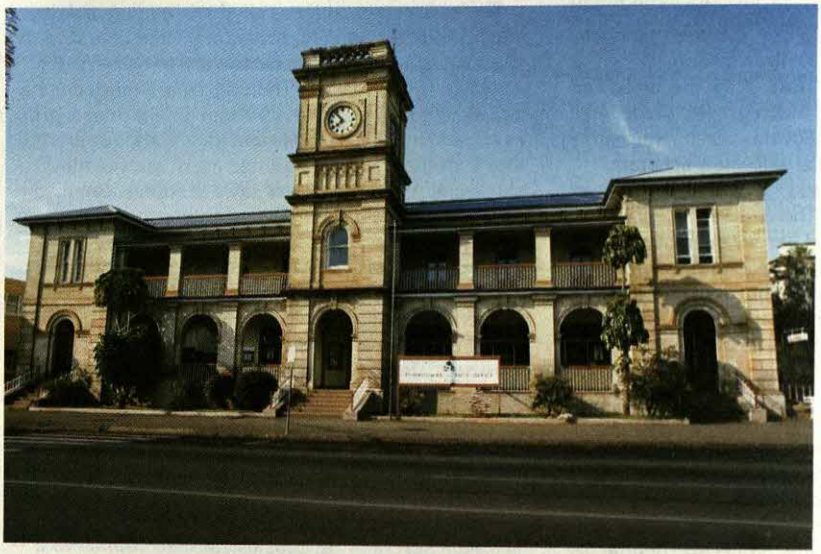
Toothache tree. See **Prickly ash.**

Toothbrush. See **Brush; Teeth.**

Toothpaste and toothpowder are substances used with a toothbrush to clean teeth. Both contain a mildly abrasive substance, such as finely powdered chalk (calcium carbonate), and a *detergent* (soaplike material). Some sweetening agent other than sugar, and flavouring oils, are included to make the agent taste good. Glycerol or a similar material is added to these basic ingredients to make toothpaste. Many toothpastes contain *fluoride,* a chemical that helps prevent decay.

Toowoomba (pop. 81,011) is the fourth largest city in Queensland, Australia. It is located on the edge of the Great Dividing Range, about 610 metres above sea level and 160 kilometres west of Brisbane. Toowoomba is a distributing centre for the Darling Downs area, which is noted particularly for wheat, beef, wool, and dairy products.

Toowoomba has a large number of thriving industries. A malt factory treats the high-quality barley of the area. The resulting products are exported. The city also has large engineering workshops for manufacturing diesel engines and machinery. In addition, it has flour mills, sawmills, clothing factories, a furniture factory, several joinery works, and brickworks. Other industries



Toowoomba's Post Office was designed by F. D. G. Stanley and built by John Gargett in 1878. It represents a colonial adaptation of the classic Renaissance style of architecture.

include butter and cheese making, pecan nut processing, and leather tanning.

Toowoomba is a well-designed city with wide streets and beautiful gardens. It is widely known as the *Garden City of Queensland* because of its fine public gardens and treelined streets. Thousands of visitors from many parts of Queensland visit Toowoomba each year during its Carnival of Flowers, which takes place in the spring.

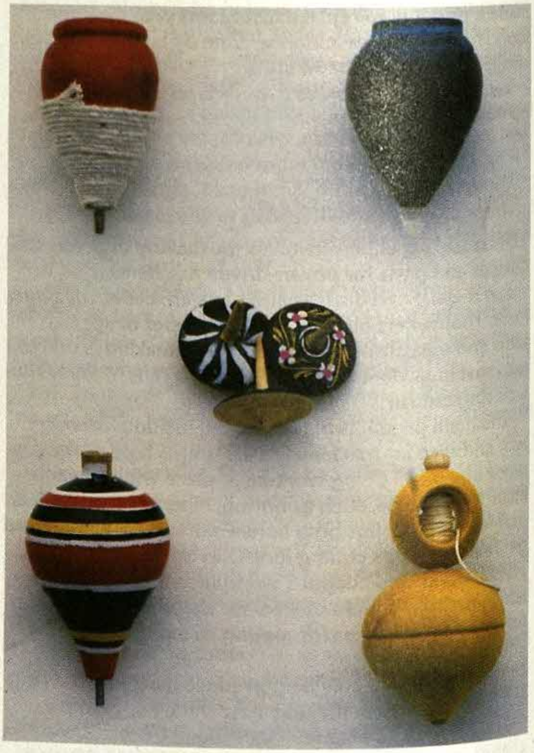
The origin of the name Toowoomba is uncertain. It may have come from *Tchwampa*—an Aboriginal corruption of *The Swamp,* which was the original name for the village that grew up in a marshy area in the 1850's. Another explanation is that the name came from *toowoon* or *choowoon*—meaning the native melon that grows in the swamp. The name could also have come from *Toowoomba,* meaning underground water. Toowoomba was proclaimed a town in 1860 and became a city in 1904.

Top is the name for a child's toy. Most tops have cylindrical or pear shapes. They are made of wood, metal, or plastic, and usually spin on a metal tip.

Kinds of tops. The best-known top receives its motion from a string that has been wrapped around it and suddenly pulled. This makes the top spin around and stay erect without being held up. Other tops spin when a centre stem is twirled between the thumb and forefinger. *Mechanical* tops receive power to spin from an inside spring that is wound with a key. In *musical* tops, holes, reeds, or whistles inside the top produce sounds when the top spins. Scientists use this spinning force in a type of gyroscopic top that helps stabilize boats and aeroplanes (see **Gyroscope**).

History of tops. No one knows exactly when people first began to use tops. But children in ancient Greece played with them, and tops have been a popular amusement in China and Japan for hundreds of years. In the 1800's, many people in the Orient became professional top spinners. They made tops do a great variety of tricks, such as jumping steps and walking up an inclined board.

Tops became popular in Europe during the 1700's. In a game called *diabolo,* the player whipped a top into the air. Sometimes the player tried to see how high the top could be sent. At other times, the top was caught in the hand from various bodily positions. Many types of self-winding tops were used in the 1800's. The *bandilor* top unwinds itself while going up an incline, and rewinds as



Tops are popular toys. The red and blue tops, *top,* were made in the United States. The small finger tops, *centre,* are from India. A Mexican top, *bottom left,* has colourful stripes. An Austrian craftworker carved the yellow top, *bottom right.*

it comes down. The top can wind and unwind itself many times. Tops were among the first toys patented in the United States. The *torpedo* top contained a ball that shot into the air when a paper cap exploded.

Topaz is a mineral composed of aluminium, silicon, oxygen, and fluorine. Topaz occurs in many colours, including deep golden-orange, yellow, brownish-yellow, pink, red, and various shades of blue. It may also be colourless. Topaz is often used as a gemstone for jewellery. In the mineral table of hardness, topaz has a hardness of 8. Topaz can scratch quartz, but not corundum, the hardest mineral next to diamond. See **Hardness; Corundum.**

The most valuable topaz is golden-orange in colour and is known as *imperial topaz.* Colourless and pale-blue topaz are much less expensive and more abundant. The colour of topaz may be enhanced by various techniques, such as heating and *irradiation* (exposure to nuclear radiation). For example, some brown topaz may turn pink when heated. Colourless or pale-blue stones may become a dark blue when treated by a combination of heating and irradiation.

Topaz is found in many countries throughout the world, including Australia, Brazil, Namibia, Nigeria, Pakistan, and Russia. Most fine-quality imperial topaz comes from Brazil. Some topaz crystals have been found that weigh several hundred kilograms. Large, beautiful topaz stones are the pride of many museums.

Yellow or brownish quartz is sometimes sold as a substitute for topaz. It can be produced by heating amethyst. In addition, blue topaz may be sold as an imitation of aquamarine. Topaz is the birthstone for November.

See also **Gem** (picture).

Topelius, Zachris (1818-1898), was a Finnish short-story writer and poet. His best-known work is *Tales of an Army Surgeon* (1853-1867), a classic of Scandinavian literature. It is a multi-volume series of historical romances that stress the role of common people in Finnish-Swedish history. The stories cover the period from the Thirty Years' War (1618-1648) to the reign of Gustavus III in the late 1700's. Topelius wrote two series of children's stories, *Tales* (1847-1852) and *Readings for Children* (1865-1896).

Topelius was born near Nykarleby, Finland. He edited a Helsinki newspaper, and was professor of history and then became president of the University of Helsinki. Topelius was a champion of Finnish nationalism, but he wrote in Swedish—the language of about 5 per cent of the Finnish people.

Topiary work is the art of training and cutting plants into ornamental shapes. Topiary work is usually done on shrubs, evergreen trees, and lawns, but decorators make topiary trees from crepe paper and wire.

Topiary work was a favourite hobby of the Romans, who made plants grow in geometrical forms such as cubes, cones, and pyramids. Later topiary designs included giraffes, dogs, pigs, and peacocks. Topiary workers also imitated such useful objects as chairs, fountains, and sundials. One design was a long row of trees shaped like elephants, with the trunk of one elephant holding the tail of the one ahead.

Topiary work was especially popular in England during the early 1700's.

Topography is the natural and artificially created surface features of the land. These include hills, valleys, streams, lakes, bridges, tunnels, roads, and cities. Topography is also the science of making an accurate and detailed drawing of such features. See also **Map; Photogrammetry; Surveying.**

Topology is a branch of mathematics that explores certain properties of geometrical figures. The properties are those that do not change when the figures are deformed by bending, stretching, or moulding. Topology makes no distinction between a sphere and a cube, because these figures can be deformed or moulded into one another. Topology makes a distinction between a sphere and a *torus* (a doughnut-shaped figure) because a sphere cannot be deformed into a torus without being torn. Topology is often called *rubber-sheet geometry* because its figures can be deformed.

Unlike Euclidean geometry, topology ignores straightness, parallelism, and distance, because deformation can alter them. Instead, topology studies such problems as the number of intersections made by a curve with itself, whether a surface is closed or has boundaries, and also whether or not a surface is connected.

Topology makes up theorems and tries to prove them, just as Euclidian geometry does. For example, the *four-colour theorem* applies to maps. The theorem states that four colours are sufficient to colour any map so that, in any group of adjacent countries, each country is a different colour. The American mathematician Kenneth Appel and the German-born mathematician Wolfgang Haken proved the theorem in 1976. The French mathematician Henri Poincaré (1854-1912) was a pioneer in topology theory.

See also **Geometry.**

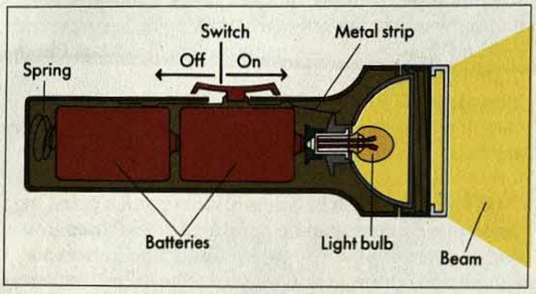
Topsoil is the surface layer of soil. It is usually 10 to 25 centimetres deep. The structure and consistency of topsoil encourages the growth of plants' root systems. Topsoil is rich in a substance known as *humus,* an important food source for such plants as small grains and grasses (see **Humus**). Topsoil also contains bacteria that are necessary for plant growth.

Because fertile topsoil is required for agriculture, landscaping, and gardening, it ranks as one of our most important natural resources. Hundreds of years may be needed for topsoil to develop. For this reason, the preservation of topsoil is one of the chief goals of soil conservation. See also **Conservation** (Soil conservation); **Lawn** (Preparing the soil).

Torah is the Hebrew name for the *Pentateuch* (first five books of the Bible). See **Pentateuch.**

Torbay (pop. 122,500) is a town on the south coast of Devon, England. It is a local government district. Torbay was formed in 1968 by uniting the three seaside resorts of Brixham, Paignton, and Torquay. The climate of the region is mild for Britain. Torquay's public gardens contain many trees and shrubs native to subtropical regions. See also **Devon.**

Torch is a portable electric light in a metal, fibre, or plastic case. A typical torch consists of a light source, power source, case, and switch. The light source is a *lamp* (light bulb). A reflector and a lens help to focus the light into a beam. Most torch bulbs are incandescent, but small fluorescent bulbs are sometimes used (see **Electric light**). Dry-cell batteries provide the power for most torches. A switch mounted on the case is used to



A torch shines as electric current is carried from the batteries to the light bulb by means of a metal strip.

turn the torch on and off. The first dry-cell torch was made in about 1898 in New York City. See also **Battery** (How dry primary batteries work).

Torfaen (pop. 88,200) is a local government district in Gwent, Wales, administered from Pontypool. Its other towns are Blaenavon and Cwmbran. Cwmbran was designated as a new town in 1949.

Cwmbran is a new town in the Torfaen district of Gwent, Wales, with gleaming modern buildings in its shopping centre.

Once a vital centre of the iron and steel industries, Torfaen now produces brakes, clothing, fibreglass, glass, jewellery, pharmaceuticals, and textiles. Steel still has some importance, and many people work in engineering firms. Forestry and arable farming are the chief rural activities.

See also **Gwent.**

Torino. See **Turin.**

Tornado is a powerful, twisting windstorm. The winds of a tornado are the most violent winds that occur on the earth. They whirl around the centre of the storm at more than 320 kilometres per hour. Most tornadoes measure several hundred metres in diameter, and many have caused widespread death and destruction.

A tornado is a rotating funnel cloud that extends downward from a mass of dark clouds. Some funnels do not reach the earth. Others may strike the surface of the earth, withdraw into the dark clouds above, and then dip down and strike the earth again. In the United States, most funnel clouds tend to travel toward the northeast. In Australia, tornados move in no preferential direction.

The winds of a tornado whirl in an anticlockwise direction in the Northern Hemisphere and clockwise in the Southern Hemisphere. People in some regions call a tornado a *twister* or a *cyclone.* A tornado over a lake or ocean is called a *waterspout* (see **Waterspout**).

Most tornadoes last less than an hour. These storms travel a distance of about 30 kilometres at a speed of between 15 and 40 kilometres per hour. Some tornadoes last several hours and measure up to about 2.5 kilometres in diameter. They may travel 300 kilometres or more at a speed of up to 100 kilometres per hour. Such tornadoes are especially destructive.

Tornadoes occur throughout the world, but mostly in the United States. Those in the United States hit chiefly in spring and early summer. No one knows how many tornadoes occur yearly because many of the storms occur in thinly populated areas and may not be reported. About 700 tornadoes have been reported annually in the United States since the mid-1950's.

The greatest killer tornado in history roared through Missouri, Illinois, and Indiana, in the United States, on March 18, 1925, and killed 689 people. This tornado was one of the largest and fastest tornadoes ever recorded. Its path measured about 350 kilometres long and up to 1.5 kilometres wide. The storm travelled at a speed of about 100 kilometres per hour.

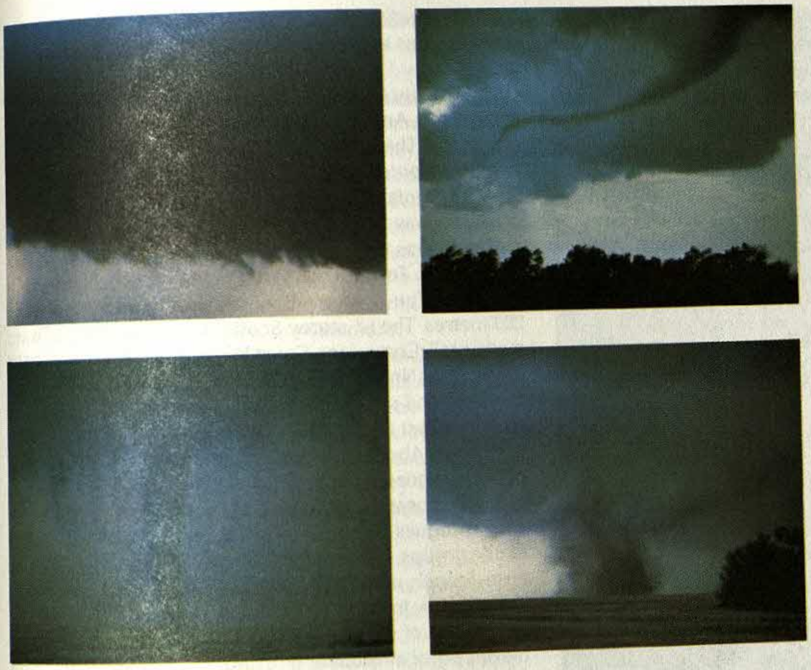
The story of a tornado. Most tornadoes in the United States strike the Midwest and the states that border the Gulf of Mexico. Scientists do not know exactly why tornadoes develop.

Most tornadoes form along a *front* (boundary) between cool, dry air and warm, humid air. A narrow zone of *cumulonimbus* (thunderstorm) clouds develops along such a front. This zone of clouds, called a *squall line,* produces violent weather. See **Cloud** (picture: Some cumulonimbus clouds).

The violent weather produced by a squall line results when a mass of warm, humid air rises extremely rapidly. As this air rises, more warm air rushes in to replace it. The inrushing air also rises and, in some cases, begins to rotate. The rotating air then forms into a tornado.

Most tornadoes occur in spring on a hot, humid day in the afternoon or in the early evening. Large thunderclouds appear in the sky, and thunder begins to rumble in the distance. A nearby cloud becomes dark and dense. Rounded masses at the bottom of the cloud start to twist. One of the twisting masses then forms a funnel cloud that gradually extends downward. Heavy rain and some hail begin to fall, and flashes of lightning occur. A hissing sound begins as the funnel cloud extends toward the earth. If the funnel touches the ground, it stirs up earth and debris. The hissing becomes a loud roar.

The violent, rotating winds of a tornado blow down almost everything in its path. In addition to the force of the wind, the explosive force of a tornado can demolish a small building. It does so primarily by causing a difference in air pressure between the inside and outside of the building. When a tornado passes over a house, it sucks up air from around the structure. The air pressure outside the house drops suddenly, but the air pressure inside remains the same. As a result, the pressure inside



The development of a tornado is shown in the four pictures on the left. First, a dense, dark cloud forms, *upper left*. Rotating air at the bottom of the cloud then forms into a narrow cloud called a *funnel, upper right*. The funnel extends toward the earth's surface, *lower left*. If the funnel touches the surface, it raises a huge dust cloud, *lower right*, and destroys almost everything in its path.

the house is greater than that outside. Because the pressure difference cannot equalize quickly enough, the building explodes outward.

The tremendous lifting force of a tornado results from a powerful updraft of air inside the funnel. Tornadoes have uprooted large trees, overturned railway carriages, and carried cars hundreds of metres.

A tornado strikes with terrible force. Its violent winds can destroy buildings, uproot huge trees, and carry cars and other large objects long distances. A tornado flattened parts of Marion, Illinois, U.S.A., *above*, in 1982, killing 10 people.

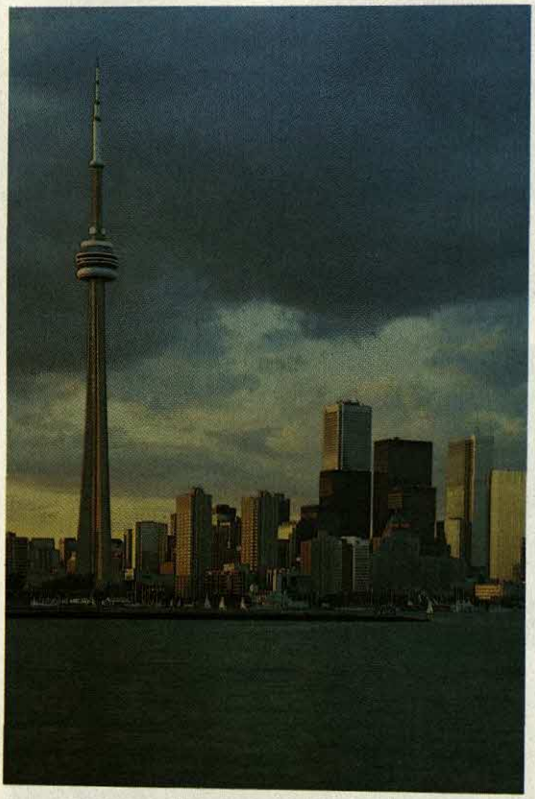
Protection against tornadoes. Weather stations obtain information from local observers, radar stations, and the pilots of aircraft when weather conditions appear favourable for tornadoes. The station then issues a warning to the people in the area of the tornado. Some communities send observers to hilltops and other vantage points to watch for funnel clouds. One type of radar, *Doppler radar*, can indicate the location of tornadoes and can also determine the speed of the wind. A tornado is a serious occurrence, and many lives have been saved by adequate tornado warnings.

A storm cellar provides the best protection against a tornado. A basement is the next best place to take shelter. In a basement, people should crouch under a table on the side of the room from which the tornado is approaching. In a building that has no basement, they should lie flat under a table or bed on the ground floor, away from any windows. Some windows should be kept open to reduce the difference in air pressure inside and outside the building and thus help to prevent the building from exploding. Mobile homes should always be vacated if a tornado is approaching. They offer almost no protection and can be easily overturned by a tornado. Outside, people should lie face down in a ditch or ravine if possible. This action would provide some protection against flying debris but would not prevent a tornado from lifting a person into its funnel.

See also **Cyclone; Hurricane; Weather.**

Torne River, also called the Tornio River, rises in Lake Torne in northern Sweden and flows eastward through northern Sweden. Then it turns southward, and forms part of the boundary between Sweden and Finland until it empties into the Gulf of Bothnia.

The Finnish people call the part of the river that forms the boundary the Tornio. But in Sweden, the river is called the Torne. The Torne River is more than 400 kilometres long.



Toronto is the capital of Ontario, Canada, and the country's chief centre of industry. Toronto's landmarks include the CN Tower, a communications and observation tower, 553 metres high. The tower, completed in 1976, is the world's highest free-standing structure.

Toronto (pop. 612, 289; met. area pop. 3,427,168) is the capital of Ontario, Canada. Toronto has Canada's largest metropolitan area population. However, more people live within the city proper of Montreal than within the city proper of Toronto. Some people consider Toronto the country's largest city, while others give that distinction to Montreal. Toronto lies on the northwest shore of Lake Ontario. It is one of the busiest Canadian ports on the Great Lakes.

Toronto is the chief manufacturing, financial, and communications centre of Canada. About a third of Canada's manufacturing industries are within 150 kilometres of the city. The Toronto Stock Exchange ranks first in the nation in daily trading volume. Toronto leads all Canadian cities in printing, publishing, and television and film production. It also ranks as a leading Canadian cultural centre. The city has Canada's largest museum and public library system.

During the 1600's and 1700's, Indians used the Toronto area as a *portage* (overland route) between Lake Ontario and Lake Huron. In 1791, John Graves Simcoe became lieutenant governor of the new British colony of Upper Canada (now Ontario). He chose the site of present-day Toronto for a new colonial capital to replace Newark, which was then the capital. In 1793, Simcoe established a settlement on the site and named it *York*. In 1834, the town was renamed *Toronto,* a Huron Indian term for *meeting place*. During the late 1800's, Toronto developed as a manufacturing and transportation centre.

In 1954, the Municipality of Metropolitan Toronto became North America's first metropolitan government federation. The Municipality, commonly called *Metropolitan Toronto,* consisted of Toronto and 12 of its suburbs. The Ontario legislature created the federation to provide a way for Toronto and the suburbs to solve various problems they had in common.

The city. Toronto has three of the world's tallest buildings. The 72-storey Bank of Montreal Tower rises 285 metres. The 68-storey Scotia Plaza building is 276 metres tall. Commerce Court West, with 57 storeys, rises 239 metres. Nearby, the CN (Canadian National) Tower, a concrete-and-steel shaft, rises 553 metres and is the world's tallest free-standing structure.

People. About two-fifths of the people of Toronto are of British ancestry. At the end of World War II in 1945, many Europeans emigrated to Toronto. People of Italian and Portuguese ancestry now make up the two largest ethnic groups. Other large groups include those of Chinese, French, and Greek ancestry.

The heavy immigration from other countries and from other areas of Canada to Toronto has greatly reduced the supply of affordable housing. The federal, provincial, and municipal governments have worked to build more public housing and to provide aid for private housing to people with low incomes.

Manufacturing. The Toronto metropolitan area ranks as Canada's chief industrial centre. More than 5,700 factories in the area produce over 7 billion U.S. dollars worth of goods yearly. About a third of the workers in the metropolitan area have manufacturing jobs. The major manufacturing activities are food processing, and printing and publishing. Other leading products include clothing; electronics and electrical equipment; and paper, rubber, and wood products.

Finance. Toronto is Canada's leading banking and financial centre. More Canadian banks and insurance companies are based in Toronto than in any other city. The Toronto Stock Exchange is the fourth largest exchange in North America in value of shares traded.

Transportation and communication. Toronto is also a major transportation centre. The region's varied products travel to many parts of the world by air and by ship via the St. Lawrence Seaway. Toronto's port handles about 1.8 million metric tons of cargo a year.

History. Iroquois Indians lived in the Toronto area before white people arrived. During the early 1700's, the French set up a mission, a fur-trading post, and a fort opposite the peninsula that helps form Toronto's harbour. In 1759, they burned Fort Toronto—also called Fort Rouillé—to keep the British from seizing it. In 1763, the Treaty of Paris gave all Canada to Great Britain.

In 1793, John Graves Simcoe named the settlement York after the Duke of York. During the War of 1812, United States troops captured and burned York. In 1834, York was renamed Toronto and received its city charter.

The demand for war materials during World War I (1914-1918) and World War II (1939-1945) brought great industrial expansion to the Toronto area. After World War II, hundreds of thousands of European immigrants settled in Toronto.

Torpedo is a self-propelled, cigar-shaped, underwater weapon used to blow up ships. It is highly complicated and designed to combat fast-moving warships and merchant ships. Modern torpedoes are difficult to detect and are extremely versatile. They can be launched from submarines, surface vessels, or aircraft. They can even ride piggy-back on a rocket to distant targets.

Torpedoes differ in size, weight, and mechanical design, according to the purpose for which they are intended. Some are designed for attacking large groups of cargo vessels shielded by warships. Other torpedoes are used in hunting deep-running submarines and aircraft carriers, or in unique battle situations.

How a torpedo operates. A conventional torpedo usually has four sections. The *nose* contains acoustic and electronic devices by which the torpedo hunts and pursues an enemy vessel. The *warhead* includes the explosive charge and the mechanism that makes it explode. The *energy* section holds the battery and the electric motor or engine. The *afterbody* houses the control and propulsion units.

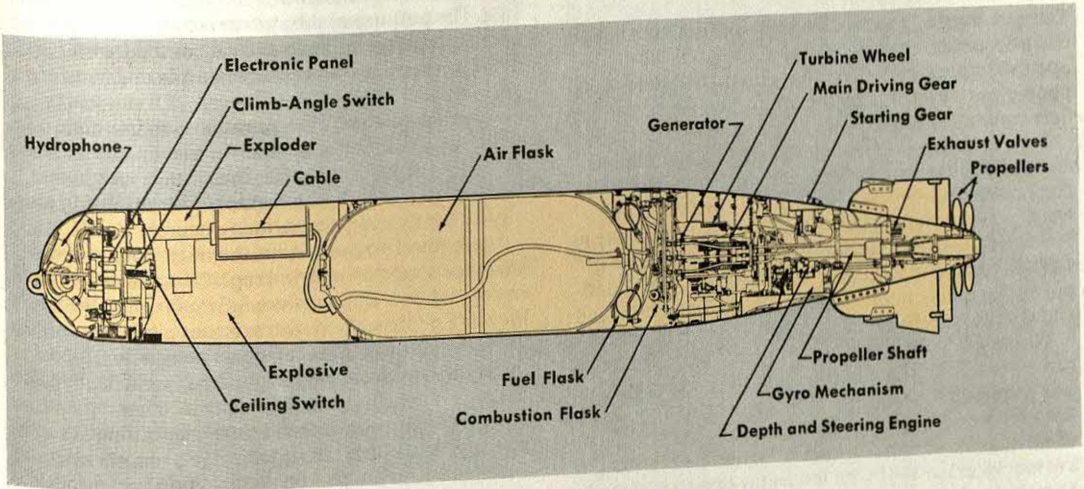
Some torpedoes are launched from a tube or rack that points the torpedo toward a target or target area. As the torpedo leaves the launcher, a starting lever in the torpedo puts the energy section into action. At the same time, power flows to the propulsion unit that drives the torpedo forward, and to the control units that stabilize the torpedo. As the torpedo speeds toward the target zone, the explosive mechanism in the warhead automatically becomes armed. Acoustic "ears" or hydrophones hunt for the sounds made by the propellers or machinery of a distant ship. When the hydrophones pick up an enemy ship by its noises, the torpedo is within *acquisition range.* At this point, it leaves its hunting course and goes straight to the target. It explodes either *magnetically,* when it nears the ship's hull, or *upon impact,* when it strikes the hull.

A special-purpose torpedo with most of these features can be guided by wire to its target. The torpedo unwinds a reel of wire as it travels to the target area. The attacking ship sends steering signals over the wire, aiming the torpedo at a target at close range.

Another special type of torpedo is the antisubmarine rocket or *ASROC.* This weapon system detects a submarine at long range and quickly computes its course and speed. Then it launches a rocket-propelled *ballistic* missile containing either an *acoustic-homing,* or sound-detecting, torpedo or a depth charge. The rocket and other parts of the missile fall away in the air. In the water, the acoustic-homing device guides the torpedo to its target. A depth charge explodes at a predetermined depth. A similar weapon, the submarine rocket or *SUBROC,* is launched from one submarine at another.

On the outside, present-day torpedoes resemble earlier ones. On the inside, the torpedo is vastly different. Modern warfare demands weapons that can operate on a broad scale and that have a high degree of reliability. Torpedoes used during World War II (1939-1945) were of simple mechanical or electrical design. They were aimed at surface vessels only, and they ran a straight course. They left a telltale wake of air bubbles behind them, and made a detectable noise as they travelled. These torpedoes could easily be evaded by a manoeuvring ship. Today's torpedoes leave no wake behind them and can track ships making evasive manoeuvres.

History. Until the 1900's, the word *torpedo* was applied to mines or any other explosive device used against ships. At first, none of these devices had means of propulsion. Those carried by surface vessels or submarines were intended to be rammed against an enemy ship or secretly attached to its hull. David Bushnell, an American, tried unsuccessfully to blow up British warships with torpedoes in 1776. In the early 1800's, the American inventor Robert Fulton successfully blew up several ships with his torpedo, but there was little interest in it. During the American Civil War (1861-1865), two large ships were sunk by *spar torpedoes.* These charges, which were mounted at the end of a pole sticking out from the attacker's bow, exploded on contact with another vessel.



A modern torpedo carries power, steering, and detonation equipment and a high explosive charge. The hydrophone detects sound vibrations from a ship's engines and guides the torpedo to the source of the sound. An air flask supplies *oxygen,* or air, needed to burn the fuel in the engine. The small engine turns propellers that push the torpedo through the water.

In 1864, a Captain Luppis of the Austrian Navy took a plan for a torpedo to the Scottish engineer, Robert Whitehead. By 1868, Whitehead had developed the first real torpedo. Powered by compressed air, the torpedo was completely self-propelled. Today's torpedo designs involve so many fields of science and are so complicated that it is not possible to credit the modern torpedo to any one person.

See also **Guided missile; Submarine.**

Torpedo ray, also called *electric ray,* is a kind of ray that lives in warm seas. The name electric ray comes from its ability to give off electricity from organs just behind the head and gills. The body of the fish is flat and broad, and ends in a slender tail. The torpedo ray uses its strange power to stun small fish and to defend itself. The shock from a full-grown, healthy torpedo ray is powerful enough to stun a person for a moment. Scientists do not fully understand how the electric organs in this fish become charged.

Torpedo rays live on the sea bed. Their mouths are so small that they would be unable to catch their prey if it were not for their ability to electrocute it first. Unlike most other fish, torpedo rays do not lay eggs. Instead, they give birth to live young, which are about 25 centimetres long.

The Atlantic torpedo is one of the largest rays, up to 1.8 metres long. A small species of torpedo ray from the Mediterranean and east Atlantic has a sandy brown back with five blue spots ringed with black and then white or cream.

Scientific classification. The torpedo ray belongs to the electric ray family, Torpedinidae. The Atlantic torpedo is *Torpedo nobiliana* and the Mediterranean torpedo is *T. torpedo.*

Torque is the amount of twisting effort that a force or forces exert on an object. The torque around any *axis* (reference line) is calculated by multiplying the force by the distance between the line of force and the axis. The torque increases as the force moves farther from the axis. For this reason, a wheel turns more easily when the force is applied farther from the centre. Torque is measured in newton metres.

See also **Force; Lever.**

Torquemada, Tomás de (1420-1498), a Roman Catholic priest, was *inquisitor-general* (chief official) of the Spanish Inquisition for 15 years. During that time, 2,000 people were executed by the Inquisition for *heresy* (beliefs contrary to those of the Roman Catholic Church).

Torquemada used the Inquisition for both religious and political reasons. He believed punishment of Christian heretics, and non-Christians—chiefly Jews and Muslims—was the only way to achieve political unity in Spain. He was partly responsible for the royal edict of 1492 that expelled 200,000 Jews from Spain. Many people admired him, but feared his power. King Ferdinand and Queen Isabella of Spain supported him.

Torquemada was born in Valladolid, Spain. He became a friar in the Dominican monastery there, and later was prior of the monastery of Santa Cruz, at Segovia, for 22 years. He served as confessor to Isabella after she became queen of Spain. Torquemada became assistant to the inquisitors in 1482, and inquisitor-general for most Spanish lands in 1483. He laid down rules of procedure and established branches of the Inquisition in various cities. He retired to a Dominican monastery at Avila in 1496, but continued to direct the Inquisition until his death.

See also **Inquisition.**

Torre, Eugene (1951-), a Filipino chess player, became, in 1982, the first Asian to qualify for the world championships, which were held that year at Toluca, in Mexico. He ranks among the leading international grandmasters (outstanding players).

Eugene Oliveros Torre was born in the southern city of Iloilo, on the central Philippine island of Panay. He began playing chess at the age of six. By the time he was 18, he had become the national chess champion of the Philippines. From 1972, Torre regularly represented his country in World Chess Olympics. In 1974, he became an international grandmaster. In 1976, during a tournament in Manila, he defeated the Soviet world chess champion, Anatoly Karpov.

Torrens is a river in South Australia. It rises in the Mount Lofty Ranges and flows for about 80 kilometres to Gulf St. Vincent, passing through the heart of Adelaide. Reservoirs on the river at Millbrook, Thorndon Park, and Hope Valley supply Adelaide with water. The Torrens Valley is noted for its market gardens.

Torrens, Lake. See **Lake Torrens.**

Torrens, Sir Robert (1814-1884), an Australian politician, introduced a system of land registration in South Australia. This system, called the *Torrens title system,* started in 1858. It was later adopted by the other Australian states and many other countries. Under the system, records of land ownership are kept in a central register, and people can prove ownership by producing a certificate of registration.

Torrens became a member of the Legislative Council of South Australia in 1851. In 1857, he served as premier of the state for one month.

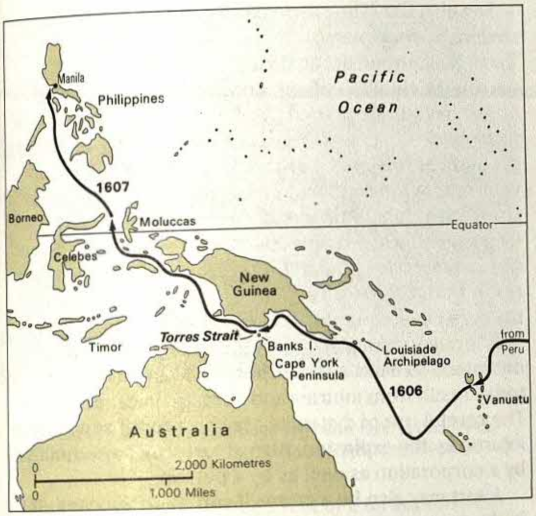
Robert Richard Torrens was born in Cork, Ireland, and educated in Dublin. He left Ireland and went to Australia in 1839.

Torrens system is a system of registering titles to *real property* (land and buildings). It is named after Sir Robert Torrens, who introduced it in South Australia in 1858. The purpose of the system is to make the transfer of real property as simple and safe as the transfer of other property, and to end repeated examination of titles.

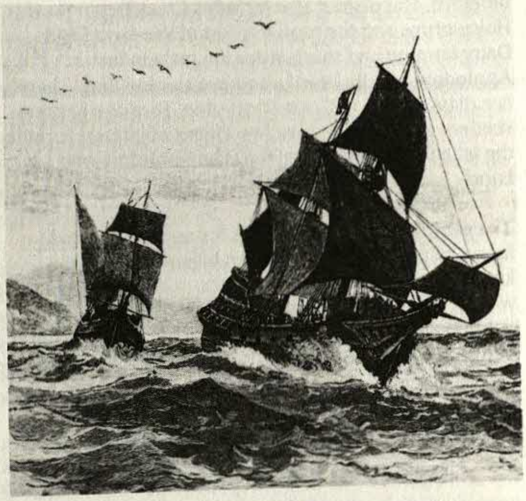
A bureau or court of registration, supervised by a registrar, operates the system. An examiner of titles usually works with the registrar. The system substitutes public registration for *conveyancing* (transferring property by deeds and other written documents).

Under the Torrens system, the owner of a piece of land files a petition with the registrar to have the land registered. Searchers make a full inquiry into the title. If they find no flaw, the registrar issues a certificate of title, which a court cannot set aside or overcome. Thereafter, the certificate will always show the state of the title and the person who holds it. Any claim or other legal restriction on the property is listed on the certificate. If someone later has a just claim against the property, an insurance fund pays the person. Registration fees maintain the fund.

After its introduction in South Australia, the Torrens system was adopted in the 1860's and 1870's by other Australian states and New Zealand. In the 1880's, it was



Luis Vaez de Torres left Peru to explore land known as *Terra Australis Incognita* (Unknown Southern Land). As he sailed toward Manila, he discovered the strait that now bears his name.



The *Los Tres Reyes* and the *San Pedrico* took 34 days to navigate the Torres Strait. Torres reported seeing islands to the south that may have been the Cape York Peninsula of Australia.

introduced into parts of Canada and the United States of America. European countries also introduced the system, as did many Commonwealth countries. In England and Wales, a Torrens system was introduced in 1862.

In Australia, the Torrens system is covered by the Transfer of Land acts in Victoria and Western Australia and the Real Property acts in other states. The system does not cover all the land in the country, but it is compulsory in some areas.

Torres, Luis Vaez de (? -1613?), was a Spanish navigator who became the first European to discover the strait that lies between Australia and Papua New Guinea. Torres discovered it in 1606, while on an expedition sponsored by King Philip III of Spain. The strait was later named *Torres Strait* in his honour.

In 1605, the Portuguese navigator Pedro Fernandez de Quiros left Peru in command of an expedition of three ships. The expedition was charged by the Spanish government with exploring territory they called *Terra Australis Incognita* (Unknown Southern Land) and converting its inhabitants to Christianity. Torres was the captain and navigator of one of the ships, the *Los Tres Reyes.*

In 1606, the ships reached land and Quiros named it *Austrialia del Espiritu Santo* (South Land of the Holy Spirit). This land now comprises the country of Vanuatu. Then, suddenly, Quiros left the expedition and sailed for Mexico. Torres and Diego de Prado, the navigator of the expedition's *San Pedrico,* continued the voyage.

The ships, following their navigation charts, proceeded southwest to reach land at 20° south latitude. Finding no land at this latitude, Torres then proceeded north-northwest. He sighted land between 11½° and 12° south latitude. Descriptions of this land from the expedition indicate that it was the Louisiade Archipelago, which lies east of Papua New Guinea. The ships then reached the southern coast of Papua New Guinea. Torres knew that a route to the Moluccas lay to the north, but unfavourable winds prevented him from sailing along the peninsula. Instead, he navigated through a narrow strait of reefs, islands, and treacherous currents.

Prado's account states that the passage through the strait took 34 days. Torres reported that he saw some big islands to the south during this passage. These islands may, in fact, have been the Cape York Peninsula of Australia. It is also possible that the explorers landed on Banks Island, climbed to higher ground, and saw the Cape York area. No member of the expedition reported a land mass as large as the Australian continent.

After passing through the strait, the ships continued to the Moluccas. They then sailed toward the Philippines and reached Manila on May 6, 1607. There, Torres wrote an account of his discoveries, but his report was ignored. For more than 150 years, cartographers, scholars, and sailors were uncertain of the existence of a strait in this area. In 1762, an Englishman named Alexander Dalrymple found Torres' report in the Manila archives and named the strait after him.

Little is known of Torres' life. Some historians believe he may have been a Spanish subject who was born in Brittany, in France.

See also **Quiros, Pedro Fernandez de.**

Torres Strait Islands are a group of islands in the Torres Strait, governed as part of Queensland, Australia. The islands include Friday, Hammond, Horn, Prince of Wales, Thursday, Tuesday, and Wednesday. The Torres Strait Islanders make their living mainly by selling pearl shell, trochus shell, and trepang. See also **Thursday Island.**

Torricelli, Evangelista (1608-1647), was an Italian mathematician and physicist. He was a friend and disciple of the Italian astronomer and physicist Galileo and became known for his discovery of the principle of the barometer in 1643. He also improved the microscope and the telescope. Torricelli wrote *Opera Geometrica* (1644). He was born in Faenza, Italy. See also **Barometer**; **Hydraulics** (Laws of hydrodynamics).

Torridge (pop. 52,600) is a local government district in Devon, England, administered from the market town of

Bideford. The district also includes Great Torrington, Holsworthy, and the tourist resort of Westward Ho! Dairy farming and tourism are the main industries, but Appledore and Bideford also have shipbuilding. There is a glass factory at Great Torrington. Torridge has fine scenery and pleasant beaches. Places of interest include the village of Clovelly and the island of Lundy (see **Lundy Island**).

See also **Devon.**

Torsion balance is a device for measuring small forces of push or pull. A torsion balance sets an unknown force against the resistance to axial twist in a wire or fibre of small diameter, measuring the twist.

In practice, a torsion balance consists of a fine strand of quartz or sometimes a fine wire of steel or gold. This wire is mounted on a holding mechanism that can be rotated in a horizontal plane, to bring the torsion balance to its zero setting. Suspended from the lower end of the fibre is a horizontal pendulum arm. Each end of the arm carries a ball of a heavy substance that resists corrosion, generally gold, lead, or stainless steel. When the force to be measured is permitted to act on these balls, they swing about, twisting the fibre. A tiny mirror mounted at the junction of the fibre and the pendulum reflects a beam of light. By noting how much this reflection moves from zero as the force acts, one measures the amount of force. It is necessary to calibrate the instrument first by twisting it with known forces. These tests must be repeated often, because molecular changes in the fibre may occur.

Torsion bar suspension is a method of absorbing the shock, or energy, that results when a car travels over uneven road surfaces and bumps. When a car with coil springs strikes a bump, the coils press closer together and absorb the energy. In torsion suspension, a torsion bar replaces the coils in the front end of the car. A torsion bar is actually a coiled spring that has been straightened. Whereas a spring presses together to absorb energy, a torsion bar is subjected to *torsion* (twisting).

A torsion bar consists of a steel rod attached to an arm from the front wheel. When the car strikes a bump, the torsion bar twists to absorb the energy. Torsion bars take up less room than coil springs.

See also **Car** (The suspension system); **Shock absorber; Spring** (metal).

Tort is a harmful act against a person that gives the person the right to collect money to pay for damage he or she has suffered. The law of tort is concerned mainly with injuries to your person, your reputation, and your property or business. For example, if someone harms your reputation by making false statements about you, you have a right to be paid for damages caused you. Other torts include someone's trespassing on your land or using your idea for a film script. Most damages that result from failure to keep a promise or perform a contract are covered under *contract law.*

A tort may take place even though one person does not intend to harm another person. Many tort cases today result from injuries and damage in car accidents. The careful use of dynamite may be a tort if someone is injured by the explosion. Also, a tort may be committed by a corporation as well as by a person.

A tort may also be a crime. If someone punches you in the nose, you can be paid for the injury. The state may also punish the person for breaking a criminal law. In tort law, the injured party normally is an individual who sues to recover damages for the harm done. In criminal law, the injured party is the government, which takes legal action to punish the wrongdoer for a crime against the public.

Related articles in ***World Book*** include:

Assault and battery
Damages
Libel
Negligence
Slander
Trespass

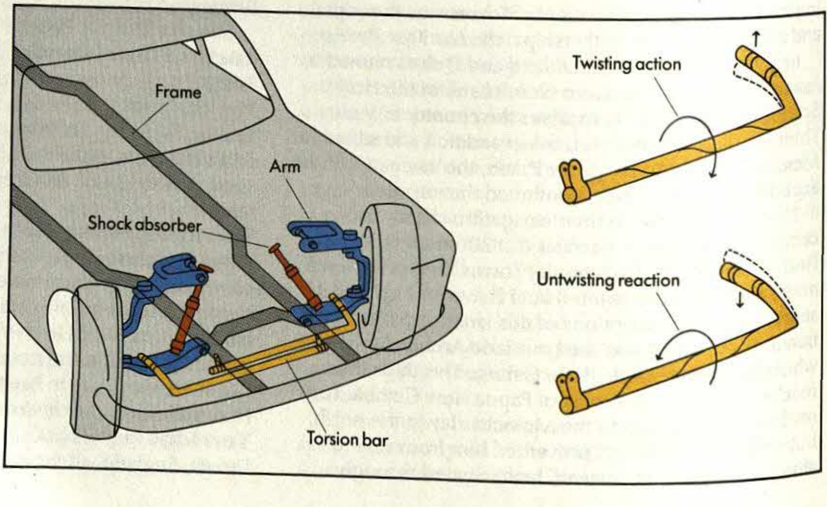
Tortilla. See **Mexico** (Food; picture); **Aztec** (Food).

Tortoise is a reptile with a shell that lives on land. Only the head, tail, and legs of a tortoise show outside its shell, and it can withdraw all these inside its shell when danger threatens. Most species of tortoise are slow-moving creatures with a high-domed shell. The shell of a tortoise is made up of plates called *scutes.* These are usually mottled with shades of brown, yellow, or black, and may be patterned with radiating lines or rings. The different *species* (kinds) of tortoise range in length from about 10 to 140 centimetres.

The head, tail, and legs of a tortoise are covered with scales. A tortoise has stumpy hind legs that look rather like those of an elephant. Tortoise hind legs are different

How torsion bar suspension works

Torsion bars are used in some cars instead of coil springs to help absorb shocks. One end of the torsion bar is attached to an arm connected to the wheel. The other end is attached to the car's frame. When the wheel hits a bump, the bar twists to absorb the jar, *upper right.* It then untwists, *lower right,* to help hold the wheel on the road and keep the car level.



The tortoise has stumpy, clublike legs and feet. When threatened, this tortoise seeks safety inside its high, domed shell.

from the flippers and webbed feet of a turtle, which is related to a tortoise. The front legs of a tortoise are flattened in shape, and are used as scoops for digging. A tortoise will dig a hole to spend the night in. In cold areas, a tortoise digs a hole to spend the winter in. To avoid very hot weather, a tortoise will drink a lot of water before digging itself into damp mud to keep cool.

There are about 40 species of tortoises. They are found in Africa, Asia, Europe, North and South America, and on certain ocean islands. Australia has no true tortoises. Most tortoises eat only plants, though some species may also eat small creatures such as frogs and worms. Some tortoises have lived for a hundred years or longer.

Tortoises reproduce by laying eggs. A female tortoise may lay as many as 50 eggs during one breeding season. The eggs are buried in a hole in the ground and left to develop by themselves. After about 3 to 12 months the young tortoises hatch out, and find their way out of the nest hole.

The world's largest tortoises live in the Aldabra Islands, in the Indian Ocean, and the Galapagos Islands, in the Pacific Ocean. These huge reptiles may measure up to about 1.5 metres long and may weigh up to 250 kilograms. The *giant Galapagos tortoise* is an endangered species, but a reserve has been established on one of the Galapagos Islands to help conserve this species.

The Galapagos tortoise ranks as one of the largest tortoises. This huge reptile measures up to about 1.5 metres long and may weigh up to about 250 kilograms.

The *African pancake tortoise* has a flat, flexible shell. When in danger, this tortoise runs quickly into a crack in a nearby rock. It then takes a deep breath and inflates its body, wedging itself tightly in the crack. The *gopher tortoise* of the southern United States is a very efficient burrower. It lives in a tunnel several metres long. The gopher tortoise leaves its hole during the day to feed on grass and other plants. Sometimes other small animals, such as snakes, share this tortoise's burrow.

Some people keep tortoises as pets. In Europe, the *spur-thighed* or *Greek tortoise* was once a common pet. Large numbers have died from being packed and taken to unsuitable climates. As a result, tortoises in the wild have become rarer. Some governments have passed laws making it illegal to export or import tortoises for sale as pets.

Scientific classification. Tortoises are reptiles that belong to the order Chelonia, family Testudinidae. The giant Galapagos tortoise is *Geochelone elephantopus.* The African pancake tortoise is *Malacochersus tornieri.* The gopher tortoise is *Gopherus polyphemus.* The spur-thighed tortoise is *Testudo graeca.*

See also **Reptile; Turtle.**

Tortoiseshell. See **Turtle** (Turtles and human beings).

Torture is the use of physical or mental pain, often to obtain information, to punish a person, or to control the members of a group to which the tortured person belongs.

Torture began as a legal procedure and was typically used to gain a confession for use as legal proof. Early Greek and Roman law permitted the torture of slaves, foreigners, and people considered dishonourable. During the A.D. 200's and 300's, torture in the Roman Empire spread to other classes of people and became more routine. Its use declined after the fall of the empire in the late 400's. But in the 1100's, certain Roman legal procedures, including torture, were revived in many parts of Europe. Civil and religious courts legally employed torture to obtain confessions until about 1800. At that time, torture was abolished and widely criticized on moral and legal grounds.

Torture slowly reappeared during the 1800's and 1900's. Military forces, police forces, and other groups with public authority began to use torture illegally to punish and control people and to gain information about civil, military, and political matters. In the 1900's, torture especially increased during political revolutions, when leaders placed political beliefs above human rights. Torture may be more widespread in the 1900's than at any other time in history.

Forms of torture have long included stretching, burning, and beating the body and suffocating a person with water. Newer and more painful methods involve electricity, pain-causing drugs, or psychological techniques. Human-rights organizations firmly oppose the use of torture.

See also **Brainwashing; Pillory; Rack; Stocks.**

Tory Island lies 14 kilometres off the coast of Donegal, Ireland. Interesting features include an ancient fort, the remains of a monastery founded by St. Columba in the 500's, and the ruins of a round tower. About 270 people live on the island.

Tory Party was a conservative political party in Great Britain. The term came from a Gaelic word meaning *pur-*

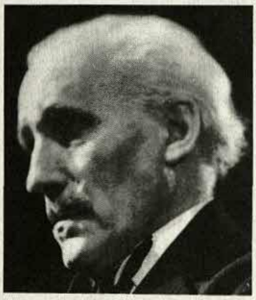
sued or *pursued man,* and was used in the mid-1600's to mean an Irish outlaw. The word was first used in English politics in 1679 to refer to those who wanted James, Duke of York, to succeed to the throne.

Eventually, the Tory Party became one of the two chief political parties in Great Britain. After 1832, the name *Conservative* began to replace *Tory.*

See also **Conservative Party; Liberal Democrats.**

Toscanelli, Paolo. See **Columbus, Christopher** (What Columbus wanted to do).

Toscanini, Arturo (1867-1957), was perhaps the most influential symphony orchestra and opera conductor of his time. When Toscanini began his career, standards of musical performance were set by conductors and musicians of the romantic school. The romantics regarded music as a means for expressing their own emotions, ideas, and performance skills. But Toscanini regarded the performer as the servant of the composer. He insisted that an analytic study of the music should form the basis of a performance. In this way, the composer's intentions could best be understood and would dominate the performance. Toscanini's approach became widely accepted in the 1900's.



Arturo Toscanini

As a young conductor, Toscanini emphasized the music of Italian composers of his day and the works of such internationally known modern composers as Claude Debussy and Richard Wagner. In later years, his performances stressed the established music of the 1700's and 1800's. Toscanini was especially respected as an interpreter of the works of the composers Ludwig van Beethoven and Giuseppe Verdi.

Toscanini was born in Parma, Italy. He attended the local music conservatory, where he studied cello and piano. Toscanini began his conducting career at the age of 19, when he led a performance of Verdi's opera *Aida* with a travelling Italian opera company in Rio de Janeiro, Brazil. In 1898, he became artistic director of La Scala, Milan, the most important opera house in Italy.

In 1908, Toscanini became a conductor of the Metropolitan Opera, New York City. He left that position in 1915. From 1921 to 1929, he again was artistic director at La Scala. Toscanini's hatred of Italy's Fascist government led him to return to the United States. From 1929 to 1936, he was principal conductor of the New York Philharmonic Orchestra. From 1937 to 1954, Toscanini directed the National Broadcasting Company Symphony Orchestra, which NBC formed especially for him. He retired at the age of 87.

Totalitarianism is a form of government in which the state has absolute control over almost every aspect of people's lives. The individual is considered a servant of the state and is allowed almost no freedom of choice or expression.

A totalitarian government is ruled by one political party headed by, in most cases, a dictator. The party sets certain economic and social goals for the state, and it outlaws any activity that could interfere with the achievement of these goals. Most totalitarian governments prohibit such groups as trade unions and trade associations. Religious practices are forbidden unless they promote the policies of the state.

Under a totalitarian system, the government uses terror tactics to suppress individuals or groups who oppose the state. The terror tactics are carried out by a secret police force and the armed services. The government also uses censorship to silence its critics. The media spread government propaganda, and the schools teach absolute loyalty to the state.

A totalitarian government controls the nation's economy through ownership or management of farmland and industry. Thus, it determines the type and quantity of crops and goods that are produced.

Various totalitarian governments have developed throughout history. In the 1920's and 1930's, however, technological advances in communication and detection systems aided the rise of extreme types of totalitarianism. Totalitarian governments of that period included those of Fascist Italy under Benito Mussolini, Nazi Germany under Adolf Hitler, and the Soviet Union under Joseph Stalin. Today, many governments have some totalitarian policies. These policies are especially common in developing nations that are building their economies.

See also **Communism; Fascism; Government** (Totalitarianism).

Totem is a symbol for a tribe, clan, or family. The Chippewa, or Ojibwa, Indians of North America first used the term for the animals or birds associated with their clans. The clan totem may be a bird, fish, animal, plant, or other natural object. Some groups consider the totem as an ancestor of the clan. A clan may have rules against killing or eating the species to which the totem belongs. Clan members are often known by the name of the totem. Some clans consider the totem holy and pray to it. Totemism, as a form of religion, may have been widespread among American Indians and black Africans. Many American Indian tribes, particularly those of the Pacific Northwest, carved the family and clan emblems on totem poles.

Totem poles may be seen in Vancouver and Victoria, British Columbia, Canada; Seattle, Washington, U.S.A.

Toucan is a bird with an enormous and, in most species, brilliantly coloured bill. Toucans live in the tropical and subtropical forests of Central and South America.

The bill of a toucan may be black, blue, brown, green, red, white, yellow, or a combination of colours. Toucans probably use their colourful bill to attract their mates. The toucan's huge bill looks heavy, but it actually weighs little because it contains a number of air pockets.

There are about 40 kinds of toucans. The largest species, the *toco toucan,* measures about 65 centimetres long. The smallest toucans, called *aracaris* and *toucanets,* grow to between 33 and 36 centimetres long. Toucans have a bristly, narrow tongue that resembles a feather. They feed mainly on various small fruit. They sometimes use their bill, which has sawlike edges, to tear off pieces of larger fruit.

Most toucans live in small flocks that sleep in hollow trees. When toucans sleep, they turn their head around and place their bill down the centre of their back. Then they fold their tail over their head.

Most kinds of toucans mate once a year. They build a nest in a hollow tree, and the female lays from two to four white eggs. The parents take turns sitting on the eggs. The eggs hatch after about 15 days, and the parents both care for the young for about 8 weeks.

Scientific classification. Toucans belong to the toucan family, Ramphastidae. The toco toucan is *Ramphastos toco.*

Touch is the sense that gives us notice of contact with an object. It is also called the *tactile sense.* We learn the shape and hardness of objects through this sense. Touching an object can give rise to feelings of warmth, cold, pain, and pressure. Free nerve endings in the tissue give the sense of pain. Touch, warmth, cold, and pain are also called *cutaneous senses.*

Touch was formerly considered one of the five special, or exterior, senses. Now it is considered a common, or general, sense because the touch organs are found all over the body.

Kinds of touch organs. There are several kinds of touch organs, called *tactile corpuscles,* in the skin and mucous membranes. One kind is found near hairs, another in hairless areas, and still another kind in deeper tissues. The sensation occurs when an object comes into contact with the sense organs and presses them out of shape, or touches a nearby hair. Nerves from the organs then carry nerve impulses to the brain.

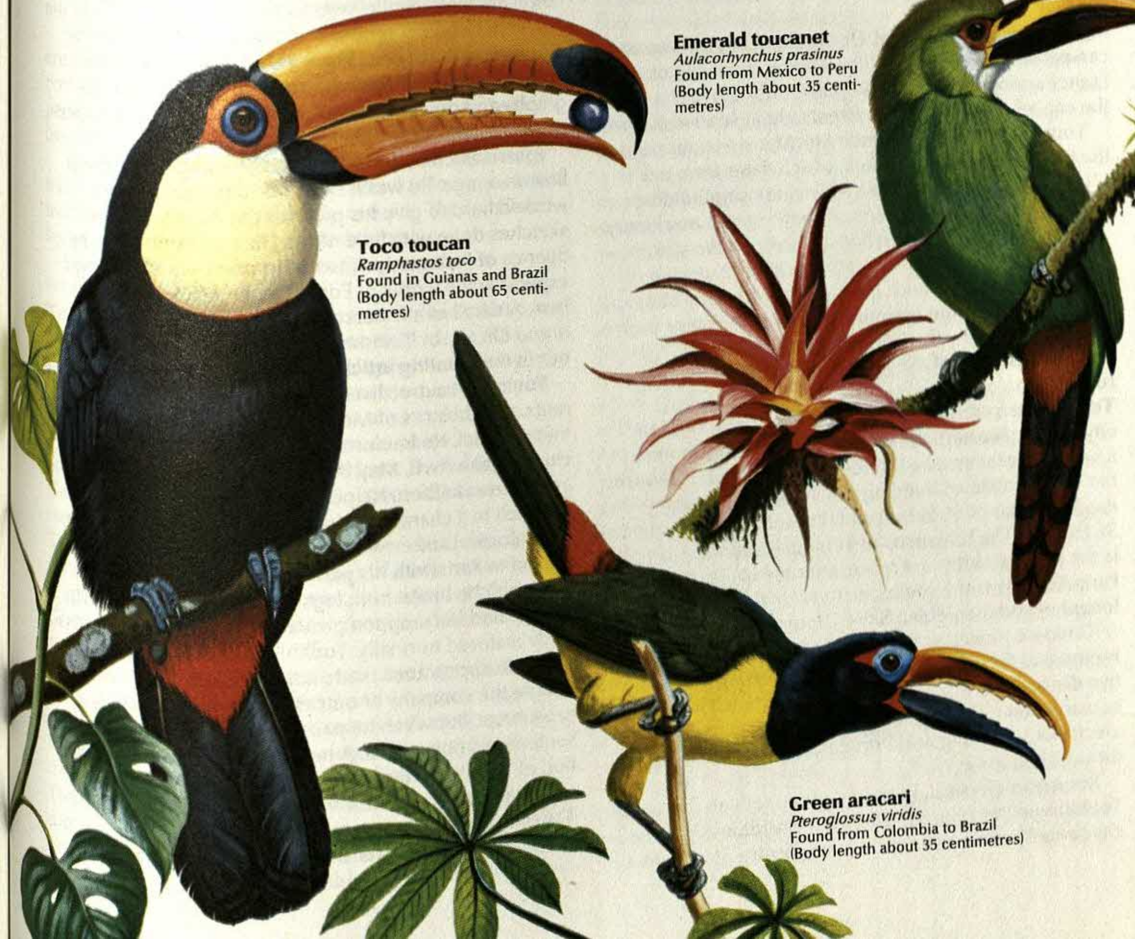
Touch is more sensitive in some parts of the body than in others. This difference is due to the fact that the end organs for touch are not scattered evenly over the body, but are arranged in clusters. The feeling of pressure is keenest where there are the greatest number of end organs. It is most highly developed on the tip of the tongue, and is poorest on the back of the shoulders. The tips of the fingers and the end of the nose are other sensitive areas.

Measurement. Scientists can easily measure keenness of touch with the *aesthesiometer.* This instrument looks like a drawing compass with two needle points. The tip of the tongue can feel both points when they are only 1.1 millimetres apart. Less-sensitive areas feel only one point at this distance. The back of the shoulders feels the two points as a single one until they are 65 millimetres apart.

The end organs for warmth, cold, and pain are also distributed unevenly. This can be discovered by running a pointed metal instrument over the skin. The instrument is colder than the skin, but it feels cold only at some points. At other points it is simply felt as pressure. Many objects act on several senses at once. For example, a hot iron that touches a person's skin would cause the sensations of pain, heat, and touch.

Scientists know there are several million points on the body that register cold, heat, pain, or touch. It is possible to map these points for the four cutaneous senses on any area of skin. People are much less sensitive to touch than insects are. See also **Pain; Insect** (Touch).

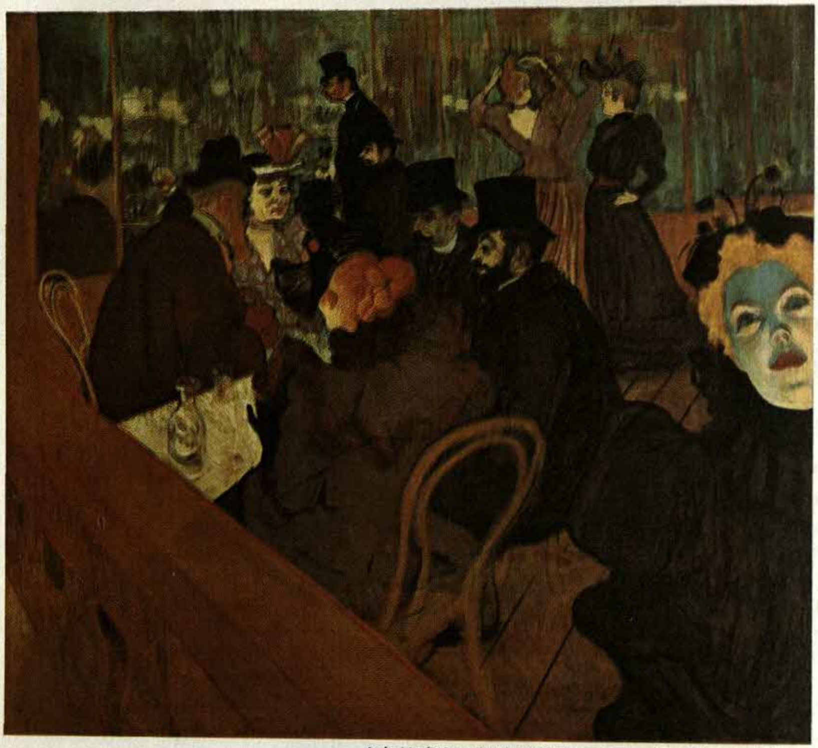
Toulon (pop. 170,167; met. area pop. 437,553) is a seaport city on the southeast coast of France. For location,



Emerald toucanet
Aulacorhynchus prasinus
Found from Mexico to Peru
(Body length about 35 centimetres)

Toco toucan
Ramphastos toco
Found in Guianas and Brazil
(Body length about 65 centimetres)

Green aracari
Pteroglossus viridis
Found from Colombia to Brazil
(Body length about 35 centimetres)



Toulouse-Lautrec's works portray night life in the cafes and music halls of the Paris district called Montmartre. The artist became particularly noted for his skill in capturing the gaiety of the district.

At the Moulin Rouge (1892), an oil painting on canvas; The Art Institute of Chicago

see **France** (political map). Docks along Toulon's coast can accommodate large ships. Toulon is the site of France's second largest naval base, after Brest. It is also the capital of the Var *department* (administrative district).

Toulon's landmarks include Ste. Marie-Majeure and the Poissonnerie (fish market), which dates from the 1500's. Toulon's main industries include shipbuilding and the production of chemicals and electric machinery.

Roman soldiers established a colony on the site of what is now Toulon in the 100's B.C. In 1942, during World War II, the French Navy destroyed many of its own ships in Toulon harbour to prevent the ships from being captured by the Germans.

Toulon, Siege of. See **Napoleon I** (Early military career).

Toulouse (pop. 365,933; met. area pop. 608,430) is a city in southwestern France. It lies along the Garonne River. For location, see **France** (political map). Toulouse has many medieval buildings, including the Romanesque church of St. Sernin and the Gothic cathedral of St. Étienne. The University of Toulouse, founded in 1229, is the second oldest in France, after the University of Paris. The city is the site of the tomb of the medieval philosopher and theologian Saint Thomas Aquinas.

Toulouse serves as the capital of the Midi-Pyrénées region and the Haute-Garonne *department* (administrative district). It is also the centre of the French aircraft construction industry. Other economic activities include electronics, printing, food processing, and the manufacture of chemicals.

Roman soldiers established a settlement on the site of Toulouse in the 100's B.C. During the Middle Ages, the city served as an artistic and literary centre of Europe.

Toulouse-Lautrec, Henri de (1864-1901), was a French painter who also became known for his lithographs and posters. He won fame for his lively pictures of Paris night life and the Paris underworld.

Essentially, Toulouse-Lautrec's paintings are superb line drawings. He was a skilled draughtsman and worked hard to give his pictures the appearance of sketches done with little effort. His work shows the influence of Japanese prints and impressionist paintings, especially the works of Edgar Degas (see **Impressionism**). A detail of a watercolour, *Trapeze Artist at the Medrano Circus,* by Toulouse-Lautrec is reproduced in colour in the **Painting** article.

Toulouse-Lautrec lived among the nightclubs, restaurants, and theatres of Montmartre, the Paris entertainment district. He immortalized many entertainers, including Jane Avril, May Belfort, Chocolate, La Goulue, and Yvette Guilbert. He portrayed them at work, catching each in a characteristic gesture and exaggerating it.

Toulouse-Lautrec was born in Albi, France, and moved to Paris with his parents in 1873. When he was 14 years old, he broke both legs in separate accidents. His legs healed but stopped growing, though the rest of his body matured normally. Toulouse-Lautrec's deformed, dwarfish appearance made him extremely sensitive. He sought the company of outcasts and rejects, including prostitutes. But when he painted them, he was neither sentimental nor critical. A museum in Albi has a collection of works by Toulouse-Lautrec.

See also **Poster** (picture).

Toupee. See **Wig.**

Touraco, or *turaco,* is any member of a family of African birds that live south of the Sahara. These birds

The red-crested touraco and many other forest species of touracos have brightly coloured feathers and long tails.

measure from about 40 to 75 centimetres long. Many of them have bright green, red, and violet-blue feathers. Touracos are the only birds that produce a green *pigment* (colouring matter) in their feathers. The green colour in other birds results from the reflection of sunlight.

Scientists classify touracos into four groups: (1) crested touracos, (2) go-away birds, (3) great blue touracos, and (4) violet plantain-eaters. Most touracos live in pairs or small groups in thick forests, but go-away birds live in dry, open areas. There are about 19 species.

Touracos are weak fliers. They climb and run along tree branches somewhat as squirrels do. Touracos eat fruit and insects and nest chiefly in trees. The females lay two or three white or greenish eggs.

Scientific classification. Touracos make up the touraco family, Musophagidae.

Touré, Sékou (1922-1984), became Guinea's first president in 1958 and held that position until his death. Touré maintained Guinea's neutrality in international politics. He supported independence movements in Africa and worked to strengthen ties among African nations. Touré rose in politics as a trade union leader in French Guinea, then a French territory. He led French Guinea to independence in 1958. Touré was born in Faranah, Guinea.

Tourette syndrome is an inherited disorder characterized by involuntary utterances and body movements. It affects more men than women. It is named after Georges Gilles de la Tourette, a French doctor who described the symptoms in 1885.

The symptoms of Tourette syndrome begin before the age of 21, usually between 7 and 10 years of age. In most cases, the first symptom is an involuntary eye blink. Most patients soon develop other *motor tics* (brief, repetitive, purposeless muscle movements). These tics may include eyebrow raising, nose flaring, mouth opening, head shaking, teeth gnashing, finger cracking, jumping, stamping, or kicking. Some patients also begin to make uncontrollable sounds, called *vocal tics.* These include grunting, barking, belching, speaking unintelligibly, and occasionally *coprolalia.* Coprolalia is the involuntary utterance of vulgar words. Some patients have short attention spans and are hyperactive.

Researchers suspect that Tourette syndrome results from an abnormality in the *neurotransmitters,* the chemicals that carry signals between nerve cells. There is no cure for Tourette syndrome, but certain drugs can help relieve the symptoms. Early diagnosis and treatment can help prevent the development of emotional problems that may result from the distressing symptoms.

Tourism is the supplying of services to *tourists.* A tourist is a person who travels away from home, either within the same country or abroad, and stays away for at least 24 hours or one night. The reasons for such travel include leisure (recreation, holidays, health, education, religion, and sport), business, and family matters. A holidaymaker, a conference delegate, and a travelling businessperson are all tourists.

A person who spends a day out, for example by the seaside, might be considered a tourist by some. But the World Tourist Organization, the international body representing tourism, defines a tourist as a person who visits a destination and stays there for at least one night before returning home.

Importance of tourism

When many people consider tourism, they think of international travel to exotic destinations. However, most tourism is *domestic*—that is, it relates to tourists travelling within their own country.

Tourism statistics. Both international and domestic tourism are dominated by industrial countries. Europe, North America, and the Pacific region receive more than two-thirds of international visitor arrivals. However, tourism is a major industry worldwide.

In the mid-1990's, the tourism industry contributed more than 6 per cent of the value of all the goods and services produced throughout the world. It also accounted for more than 7 per cent of global capital investment and 13 per cent of world consumer spending. Experts estimated that tourism supported more than 130 million jobs worldwide and contributed more than 5.6 per cent to total tax payments.

Aspects of tourism. The tourism industry is made up of all the businesses that directly provide goods or services for the business and leisure activities of tourists. The industry includes international and domestic airlines; shipping lines and ferry operators; railway, bus, and taxi operators; accommodation suppliers; restaurants, clubs, and other catering establishments; tour and excursion operators, travel agents; managers of entertainment facilities (theatres, cinemas, discotheques, night clubs, funfairs, and so on); theme parks; national parks and heritage attractions; manufacturers and retailers of souvenirs; visitor information centres; and conference, convention, and meeting centres. Many of these businesses serve nontourists too.

Effects of tourism

Tourism creates many job opportunities. Tourism is a *labour-intensive* industry—that is, it requires a large number of workers. But most tourism is *seasonal,* that is, there are times in a year when visits to a destination reach a peak, especially at seaside and ski resorts. As a result, many tourism jobs are part-time and casual. The majority of tourism jobs are also low-skilled and low-paid. However, the large numbers of people that tourism employs and the links it has to other industries, such as catering and restaurant work, mean that governments actively encourage tourism development.

Tourism has brought economic benefits to many places in terms of employment and income. But it has also created problems when it has grown too rapidly or in an uncontrolled way. Experts believe that tourism destinations go through a "life cycle." After a destination is discovered by tourists, it undergoes rapid development. Large numbers of tourists who visit the destination then change its character by affecting its physical environment and the culture of its people. Changes to the destination may mean that whatever attracted tourists to it in the first place is lost. The destination will then go through a stage of stagnation and possible decline.

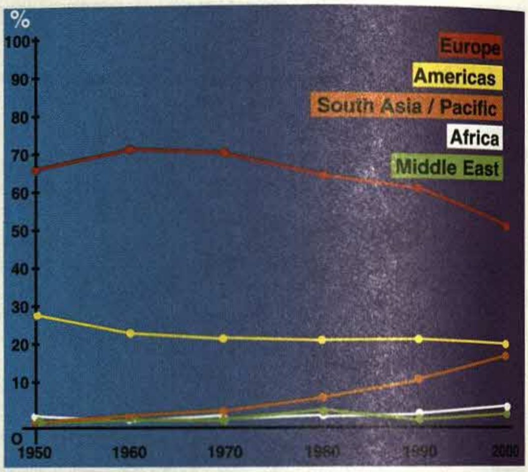
By recognizing this "life cycle," the tourism industry has revived many "tired" destinations. Atlantic City in the United States increased its visitor arrivals after a long decline by allowing casino development. Other cities have built new attractions such as conference halls, museums, art galleries, and leisure centres. Some have hosted a major event, such as the Olympic Games.

Environmental effects. In many regions, the natural environment is a major tourist attraction. Bird- and whale-watching, scuba diving, wildlife photography, and safaris are some of the major growth areas in the field of nature-based tourism. International attractions of this type include the game parks of eastern and southern Africa, the national parks of North and South America, and the unspoilt habitats of Antarctica. The annual migration of whales has become an important attraction in many parts of the world. Governments in Australia, Canada, New Zealand, and the United States have passed laws to minimize the disturbance of whales by the ships and boats of tourism operators. Tourism developments on coasts and estuaries, particularly in Southeast Asia and the Pacific, have disturbed bird and fish breeding and feeding grounds.

Uncontrolled hotel development has also caused many problems in coastal resorts. As well as damage to sand dunes, some hotels have been built too close to the neighbouring beaches, leaving them in shadow for much of the day.

Pollution is another problem. Water pollution may cause a decline in water quality for swimming. It may also affect the growth of coral reefs. The coastal resorts of Pattaya and Phuket in Thailand have recently embarked on a major programme to stop the water pollution caused by inadequate sewage systems.

Governments and the tourism industry are developing campaigns to build tourism that will last without harming the environment. National and international tourism industry associations have developed codes of ethics and environmental conduct. Several major companies, such as American Airlines and British Airways, have introduced programmes designed to promote recycling and better use of resources. Some governments may also act to restrict visitor numbers to sensitive sites such as national parks. The small Himalayan country of Bhutan, for example, restricts the number of international tourists seeking to enter as visitors.



Source: World Tourism Organization estimates

Regional share of international tourist arrivals

Cultural effects. Tourism has exposed destinations in developing countries to the behaviour and values of visitors from foreign, mostly Western, cultures. In some destinations, the local residents copy the visitors, and the culture changes. Old customs die out. Traditional foods are replaced by dishes that foreigners expect and prefer. In many locations, craftworkers make low quality, inauthentic souvenirs for a quick profit.

In many places, however, local communities have been reinvigorated by tourist interest in arts, crafts, and culture. In Bali, Indonesia, the local theatre has been adapted for tourist consumption. But it is still also produced for the Balinese in its original form.

History

The first tourism industry probably grew up about 3,000 years ago around the supply of goods and services to pilgrims journeying through India or other parts of Asia. Many of the ancient pilgrimage routes in India, such as those of Buddha, are still extensively used today.

Greece and Rome. In the 400's B.C., the Greek historian Herodotus toured extensively, visiting Egypt, Mesopotamia, Palestine, southern Russia, and the northern fringe of Africa. The ancient Romans invented many characteristics of modern tourism. Their holy days—100 or more work-free days during the year devoted to religious feasts—were the basis of the holidays of today. The Roman world also had its souvenirs and seaside resorts. The Romans escaped the stresses of city life by visiting Naples and the Italian Riviera.

The Romans also travelled to other parts of the Roman Empire. Those who could afford it took trips to Egypt and Greece in order to visit temples and see the local culture. In the A.D. 100's, the world's first tourist guide book was produced by the Greek geographer Pausanias for Roman visitors to Greece.

In the Middle Ages, trade and pilgrimage were the main reasons for travel. Christians travelled to cathedral towns and religious centres, such as Rome, Canterbury in England, and the sites of the Holy Land. Hostels and inns developed along the pilgrimage routes. Souvenirs were regarded as an essential part of the pilgrimage, so that people might prove where they had been in their search for salvation. Many pilgrimage routes and sites remain tourist attractions today.

In the later Middle Ages, people travelled more for pleasure than religion. In the 1500's, Paracelsus, the father of modern medicine, argued that mineral springs were beneficial to health. The spa resorts of Austria, Germany, Hungary, and Italy became well established as destinations for pleasure travellers.

The Grand Tour. The Renaissance saw the start of the so-called "Grand Tour," in which young aristocratic men travelled through Europe to become both educated and cultivated. It was considered important, especially for young, educated Englishmen, to see the European world. Sightseeing became an essential part of tourism—cathedrals and churches, palaces, and the sites of ancient Rome were all regarded as important.

The Renaissance, with its emphasis of the education of the complete man, also saw the first wave of student travel to the European continent. This continued through the 1600's. The students usually made their grand tours at the age of 16, just after graduation from university, and each trip took between 1 and 5 years. The Grand Tourists were accompanied by *chaperons* (people who looked after their welfare). The wealthier travellers also had *entourages* (large staffs), which included valets, coachmen, footmen, accountants, and landscape painters. *Letters of credit* were introduced in the 1700's. These were letters from a tourist's bank allowing the tourist to draw money up to a certain amount while abroad. They were the equivalent of modern traveller's cheques (see **Traveller's cheque**).

The 1800's. The Industrial Revolution led to a massive change in travel patterns and behaviour. The development of the railway and the steamship made inexpensive and rapid travel possible for the new middle and working classes. These developments also led to the establishment of mass tourism resorts in the United Kingdom (UK), such as Southend, Margate, and Blackpool.

The British Romantic movement, led by poets such as William Wordsworth, created interest in natural scenery. In the early 1800's, travel books reflected this trend. In Europe, the English Lake District, the Scottish Highlands, and the Swiss Alps all became tourist destinations. In North America, Australia, and New Zealand, the combination of the railway with scenic appreciation led to the establishment of the first national parks—Yellowstone National Park (Wyoming, U.S.A., 1872), Royal National Park (New South Wales, Australia, 1879), and Banff National Park (Alberta, Canada, 1885).

Modern mass tourism commenced on July 5, 1841, when the first conducted excursion train arranged by Thomas Cook left the railway station in Leicester, England. Cook became the world's first tour operator when he obtained a reduced "group rate" of one shilling per head for a rail journey from Leicester to Loughborough. Cook went on to organize other trips, negotiating with the separate railway companies who ran the UK's railway system at that time. Cook's tours were initially organized for temperance groups and schoolchildren. Travelling purely for pleasure was a later development.

Cook started to run tours as a commercial business in 1845, with a tour from Leicester to Liverpool and North Wales. He organized the first tours to major events such as the Great Exhibition in London in 1851 and the World's Fair in Paris in 1855. Cook also offered walking tours of the Swiss Alps. In 1867, he organized the first tour to the United States.

Edward Pritchett, *Venice from the Piazzetta looking towards Codussi* (1800's); London.

Venice has attracted tourists for hundreds of years. In the 1800's, it was an essential part of the "Grand Tour" of Europe, *left;* today, tourists relax at an open-air cafe, *below.*

In 1873, Cook invented the Circular Note, an early form of traveller's cheque. In 1872, he organized the first conducted round-the-world tour. The trip was reported as it happened in *The Times.* The tour began in London, crossed the Atlantic to New York, then continued by train to San Francisco, by ship to Japan and then overland to Cairo, where it connected to existing Cook's tours back to London. Cook's operations were popular. By 1880, there were about 60 Thomas Cook & Son travel agency offices around the world, and 500 hotels that accepted Cook's traveller's cheques. See **Cook, Thomas.**

As middle-class tourists began to travel to destinations traditionally favoured by rich Grand Tourists, the wealthy upper classes developed new forms of luxury travel. In 1883, the Orient Express was created by Georges Nagelmackers, a Belgian tour operator. It was the first European train with sleeping and restaurant cars. The Orient Express originally went from Paris to the Black Sea and later extended its run to Istanbul, Turkey. The full service to Istanbul ended in 1977, but services over parts of the route continue to run. The Orient Express was richly and comfortably finished. The late 1800's was also the age of luxury ship travel. The first passenger liners were palatial, providing the tourist with a style of living that even the best hotels could not offer.

In the 1920's, U.S. film stars visited the French and Italian Rivieras and made them popular. The fashion of sunbathing began. Despite the health hazard caused by too much exposure to sun, it remains popular today. This fashion helps explain the popularity of the Mediterranean and Caribbean as tourist destinations.

Following the end of World War II (1939-1945), pleasure travel became even more accessible through increases in car ownership, spare time, and spending money. The development of commercial jet aircraft in the 1950's and 1960's allowed more people to travel longer distances more quickly and more cheaply than before. Mass air travel required larger airports to meet the increasing number of travellers. The same period saw the building of large hotel resorts in coastal areas.

Tourism growth also led to the development of *package* (inclusive) tours. The first such tour, run by a UK based company called Horizon, went to the Mediterranean island of Corsica in 1950. The package tour, with its planned, tightly scheduled itinerary, was the major example of mass tourism in the 1900's. As more people travelled, new attractions were developed. Large theme parks, such as Disneyland and Disneyworld in the United States, were built to accommodate the demand for new, inexpensive, packaged tourism experiences.

In the early 1980's, tourism received a setback as the price of aviation fuel increased at times of political crisis in the Middle East. However, tourism has grown steadily, even during economic recession. Between 1970 and 1990, world tourism grew by more than 260 per cent.

Tourism today. The 1980's and 1990's have seen the development of new forms of travel. Although package holidays are still a major part of the tourism industry, increasing numbers of tourists are travelling to experience culture, heritage, and the environment. In response to changes in lifestyles, short-break and weekend holidays are increasingly popular.

In the 1990's, global tourism grew at an average of about 4 per cent annually. Today's international tourists are choosing different destinations from those selected by their predecessors. Because of the rapid economic growth of China, Indonesia, South Korea, Taiwan, and Japan, the Asia-Pacific region is becoming a major centre for international tourism. Newly developing tourist locations such as Bali in Indonesia, the Great Barrier Reef in Australia, and centres in Thailand and Singapore are expected to maintain their growth for years to come.

J. Allan Cash Photolibrary

Resorts like Fuengirola in Spain, *above,* have grown rapidly in recent decades with the advent of package tours.

Tourmaline is a mineral commonly found in rocks called *granitic pegmatites.* Tourmaline is slightly harder than quartz, and it wears well as a gemstone. The chemistry of tourmaline is complex. The mineral consists of various elements combined with boron and silicon.

The word *tourmaline,* though widely used as a gem name, actually refers to at least six mineral species. Most of the gemstones in the tourmaline group are cut from the minerals *elbaite* and *liddicoatite.*

The minerals in the tourmaline group display the broadest range of colours of all gemstones. Tourmalines range from *achroite* (colourless) to *schorl* (black), and various shades and combinations of red, pink, green, blue, violet, yellow, and brown are known. Blue and violet tourmalines are called *indicolite.* Tourmaline crystals may also be *colour-zoned* along their length to form *bicolour stones.* Bicolour stones have a different colour at each end. For example, some have green at one end and red at the other. *Watermelon tourmalines* are colour-zoned from the centre outward and so may have a red centre and green outer rim. The change in colour may be very sharp and dramatic.

Tourmaline has several unusual properties. For example, it becomes electrically charged when subjected to changes in heat or pressure. As a result, it is used in various kinds of electrical instruments. Tourmaline also has a property called *pleochroism* or *dichroism*—that is, tourmaline crystals show a darker colour when viewed lengthwise than at right angles.

Tourmalines are found in many parts of the world, including Brazil, Madagascar, southern Africa, south-central Asia, and the United States.

See also **Gem** (picture); **Polarized light.**

Tournament. See **Knights and knighthood** (Tournaments: picture).

Tourneur, Cyril (1575?-1626), was an English dramatist. He is thought to be the author of *The Revenger's Tragedy* (1607). Many critics consider this play to be one of the most powerful Elizabethan tragedies outside the work of Shakespeare. It is remarkable for its gloomy intensity and complex beauty of imagery, and for the sweep and rapidity of the plot's development. Tourneur also wrote *The Atheist's Tragedy* (1611).

Tourniquet is a tight, twisted cloth wrapped around a limb to control bleeding. The pressure of the tourniquet slows blood supply to the injured area and thus diminishes blood loss. People formerly applied tourniquets as a first aid procedure. But in many cases, improper use of the tourniquet impaired blood circulation in the injured limb and caused *gangrene* (tissue death). Many people have had limbs amputated and have even died because of improperly applied tourniquets. Thus, only doctors and specially trained medical personnel should apply tourniquets.

Because of the risks associated with them, tourniquets are rarely used today. Instead, medical personnel apply direct pressure to the wound or use special inflated airbags to slow bleeding in emergency situations. The airbags safely compress the injured limb without impairing blood circulation.

Tours (pop. 133,403; met. area pop. 271,927) is a historic city and important economic centre in western France. It lies in the scenic Loire Valley, along the Loire and Cher rivers (see **France** [political map]).

The countryside around Tours has many old castles. The city's landmarks include the ruins of the Old Basilica of Saint Martin, completed in about 470; and the Cathedral of Saint Gatien, which dates from the 1200's. Tours is the capital of the *department* (administrative district) of Indre-et-Loire. The city's industries include banking, insurance, and the production of electric equipment, farm machinery, machine tools, medicines, and wine.

Roman soldiers founded the town of Caesarodunum on the site of what is now Tours in the 50's B.C. In A.D. 732, the Christian Franks, a European people, defeated invading Muslim armies in a great battle that began near Tours and ended near Poitiers (see **Army** [Famous land battles]). During World War II (1939-1945), German bombers heavily damaged parts of Tours. These areas were soon rebuilt.

Toussaint L'Ouverture (1743-1803), François Dominique Toussaint-Bréda, was a black revolutionary and general who became ruler of Haiti. His parents were black slaves. Toussaint taught himself to read and write and became well educated, even though he was a slave until he was almost 50 years old. His name, L'Ouverture (The Opening), was taken from a remark by the French governor of Haiti, that "this man finds an opening everywhere," referring to his ability to break through enemy lines.

After the news of the French Revolution reached the French colony of Haiti, various uprisings took place. A slave revolt broke out in Haiti in 1791, in which Toussaint soon became a leader. The black army first fought against France. But in 1793, the National Convention in France proclaimed freedom for all the slaves. Toussaint then came to the aid of the French against the Spanish and the British, who were fighting the French in Haiti.

Toussaint L'Ouverture

In 1799, a civil war broke out between the blacks and the *mulattoes* (people of mixed black and white parentage). Toussaint, as leader of the blacks, became ruler of the island. Haiti prospered under his rule.

In 1802, Napoleon signed the Peace of Amiens, which freed his hands in Europe. He decided to subdue Haiti, and announced the reestablishment of slavery. Toussaint resisted, and Napoleon sent an expedition against him. Toussaint was captured. But he was freed on condition that he would not work against the French again. He was later caught in a plot against the French and taken to France. Toussaint died in prison.

Tovey, Sir Donald (1875-1940), was a British pianist, composer, and teacher. He is best remembered for his brilliant *Essays in Musical Analysis*. These volumes of essays are versions of programme notes that he wrote when he was Reid Professor of Music at Edinburgh University. His compositions reveal his great skill and sensitive approach to music.

Tovey was born in Eton, in what is now Berkshire, England. He was educated privately and at Balliol College, Oxford, graduating in 1898. Tovey gave a series of chamber music concerts in London from 1906 to 1912 and performed many of his own compositions. He made his American debut in 1925, and made a tour of the United States in 1927 and 1928. Tovey was knighted in 1935.

Sir Donald Tovey

Towboat. See **Tugboat.**

Tower is an architectural structure whose height is much greater than its width or its thickness. Towers are generally taller than their surrounding structures. They may stand alone or be attached to walls or buildings. The first towers were built for military or religious purposes, but over the centuries towers have assumed other uses.

Towers were rare in ancient times. One of the most famous early towers was the Lighthouse of Alexandria, Egypt, built during the reign of Ptolemy II (283-246 B.C.). During the Middle Ages in Europe, people erected masonry towers along the walls of castles and cities for military defence. The Tower of London is a prominent example of this type of structure. In the late Middle Ages, many European cities built tall slender bell towers on their city halls. These bell towers also served as watchtowers.

Towers are important in religious architecture. People who worshipped the sun and stars built towers so that their priests could be closer to the heavens. Buddhists build towers called *pagodas*. A crier calls Muslims to prayer from a tower called a *minaret*. In the 500's, Christians began to build free-standing bell towers beside their churches. These are called *campaniles,* from the Italian word for *bell.* After about 1000, Christians built steeples and other towers attached to the church itself.

Today, many skyscrapers are often called towers. Towns use water towers to create the pressure needed to pipe water to homes and businesses. Broadcasting towers support radio or TV aerials. The world's tallest self-supporting structure is the CN (Canadian National) Tower in Toronto, Ontario, Canada. This 553-metre broadcasting tower was completed in 1976.

Related articles in *World Book.* See pictures with the **Architecture** article. See also:

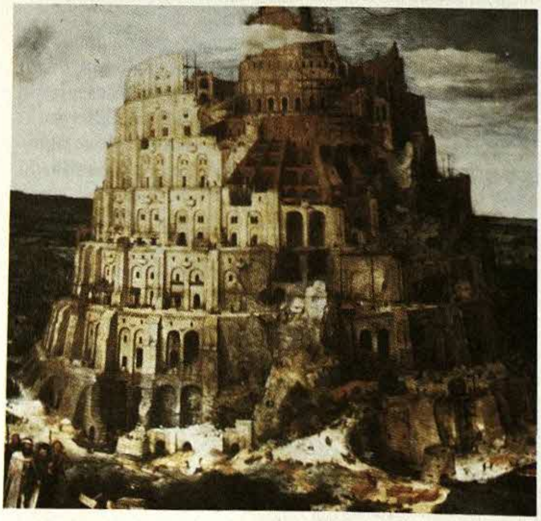
Campanile
Eiffel Tower
Leaning Tower of Pisa
Lighthouse
Minaret
Pagoda
Seven Wonders of the Ancient World (The Lighthouse of Alexandria)
Toronto (picture)
Tower of London

Tower Hamlets (pop. 153,500) is a borough within the Greater London area. It is situated in east London and was created in April 1965, from the former metropolitan boroughs of Bethnal Green, Poplar, and Stepney. Its southern boundary runs along the north bank of the River Thames. Tower Hamlets includes the Isle of Dogs and other parts of London's docklands. These areas were redeveloped in the 1980's, creating new industries, homes, and a new light railway. The world-famous Petticoat Lane market takes place every Sunday in Middlesex Street. Tourist attractions in the borough include the Tower of London.

Tower of Babel was a tower in Babylon, a city in ancient Mesopotamia. It was shaped like a pyramid with terraces—a design known as a *ziggurat.* The tower had seven storeys plus a small shrine on top. The Babylonians called the tower *Etemenanki,* which meant *the house of the foundation of heaven and earth. Babel* is the Hebrew name for *Babylon. Babylon* meant *gate of the god* in the Babylonian language.

Scholars know little about the tower. But a story of its construction is told in the Bible, in Genesis 11: 1-9. According to the Bible, Noah's descendants settled in southern Mesopotamia after the great Flood. They started to build a great city, including a tower that would reach to heaven. But God did not want the city completed, so He made the builders speak different languages. The builders then could not understand one another, and so they stopped working and scattered over the earth. The ancient Hebrews used this account to explain the origin of languages.

See also **Babylon.**



The Tower of Babel was a terraced pyramid, called a *ziggurat,* in the ancient city of Babylon. The Flemish artist Pieter Bruegel the Elder painted this rendition of the tower in 1563.

Tower of London is a group of stone buildings in the East End of London, on the north bank of the River Thames. It has served as a fortress, a prison, and a palace. The oldest of the buildings, a central tower called the White Tower, was built by William I, the Conqueror, and dates from the late 1000's.

A shallow *moat* (ditch) and a high stone wall surround this group of buildings. The buildings have great thick walls. The structure is so strong that in former days it could have held off a whole army. The British Department of the Environment now uses the buildings chiefly as a showplace and museum. The museum's armour collection was started by Henry VIII in the 1500's.

The Tower of London also houses the royal jewel office. Here the crowns, sceptres, and other royal treasures of the English rulers, known as the *crown jewels,* are closely guarded (see **Crown jewels**). Tower of London guards are called *Yeomen Warders* (see **Yeoman**).

Many famous people were imprisoned in the tower's damp, dark cells. Lady Jane Grey came up through the Traitor's Gate on the Thames to be beheaded. The young Edward V and his brother, the Duke of York, were put in the tower after their uncle, Richard III, became king in 1483. The boys were never heard of again. Sir Roger Casement, a leader of the Irish Rebellion of 1916, was imprisoned in the tower until his execution.

See also **London** (picture).

Tower of Silence is a platform on which the Parsees of India place the bodies of their dead for the vultures to eat. Generally, a tower of silence is no more than 10 metres high. It stands over a deep pit. The bodies are laid on a grating at or near the top of the tower. After the vultures have eaten the flesh, the bones drop through the grating into the pit below.

See also **Funeral customs; Parsees; Zoroastrianism.**

Town is a community of closely clustered dwellings and other buildings in which people live and work. It may be large or small. Most people use the word *town* to refer to a municipal unit larger than a village and smaller than a city.

See also **City; Local government; Town planning; Village.**

Town crier was a person appointed to make public announcements. The town crier was important in Europe, particularly in England, before newspapers were common. The crier sang out the latest news at every corner, and announced the time of town meetings and other events of public interest. The town crier largely disappeared when the printing press, newspaper, and other forms of communication came into general use after the 1750's. Today, some British communities still have a town crier.

Town planning is the process of guiding the development of cities and towns. Town planners—the people who direct the process—advise local governments on ways to improve communities. They also advise governments and property developers who are planning entirely new communities.

Town planners deal chiefly with the physical layout of communities. They make proposals designed to beautify communities and to make life in them comfortable, enjoyable, and profitable. Their proposals include recreation areas, shopping centres, and plans to improve transportation and parking facilities.

A planner creates a *master plan* (overall plan for the community) and uses it as the basis for all the work. A town planner's suggestions must follow the master plan. For example, the plan might restrict the height of buildings in residential areas. Town planners must follow this restriction for any residential area of the community.

Town planners try to anticipate future trends. They attempt to forecast such developments as large increases in population and large losses in industrial activity. Their predictions help a government plan for the future.

Town planning began with the first cities—in about 3500 B.C. Ancient peoples set aside areas for housing, worship, and other activities. They built walls around their communities for protection against enemies. Throughout history, people have done some planning for their communities. But the planning has not kept pace with the growth of urban communities that has taken place in many countries. Many urban communities have become dirty, noisy, overcrowded, and run-down.

During the 1900's, governments have greatly increased town planning activities in an attempt to help solve the many problems of cities and towns. For a discussion of these problems, see the *World Book* article on **City** (City problems).

The master plan

The preparation of a master plan ranks among the most important duties of a town planner. A master plan, also called a *comprehensive plan,* includes diagrams and models that show a community as it is and as the planner believes it should exist in the future. A master plan shows how land should be used and how public facilities—such as fire and police stations, parks, schools, and transportation—should be improved or increased.

Preparing the plan. A town planner may consult many other professional experts in preparing a master plan. These experts might include architects, economists, educators, engineers, finance specialists, geographers, lawyers, political scientists, statisticians, and specialists in air and water quality. The town planner also seeks advice from local people who will be affected by the plan. These people include business people, homeowners, and members of citizens groups. Such consultation is called *advocacy planning.*

Proposals of the plan. A master plan aims to make community life more comfortable, enjoyable, and profitable. A good plan separates residential areas from industrial areas. It provides transportation facilities that enable people to get to and from shops, offices, and factories quickly and easily. It also provides enough recreation areas, schools, and shopping facilities.

A computer-generated drawing, *above,* may be used by planners to show proposed changes to an urban area.

The major part of a master plan recommends how the land should be used. The plan divides the community into sections. It classifies some sections as residential areas, others as commercial and industrial areas, and the rest as public facility sites. It divides these major sections into smaller districts, each with certain building restrictions. For example, the plan reserves some parts of residential areas for houses only and some for both houses and small apartment buildings. The master plan may permit retail trade, wholesale trade, and light manufacturing in some commercial and industrial districts but forbid heavy manufacturing there. The plan may include proposals for major changes in essential services, such as sanitation and transportation.

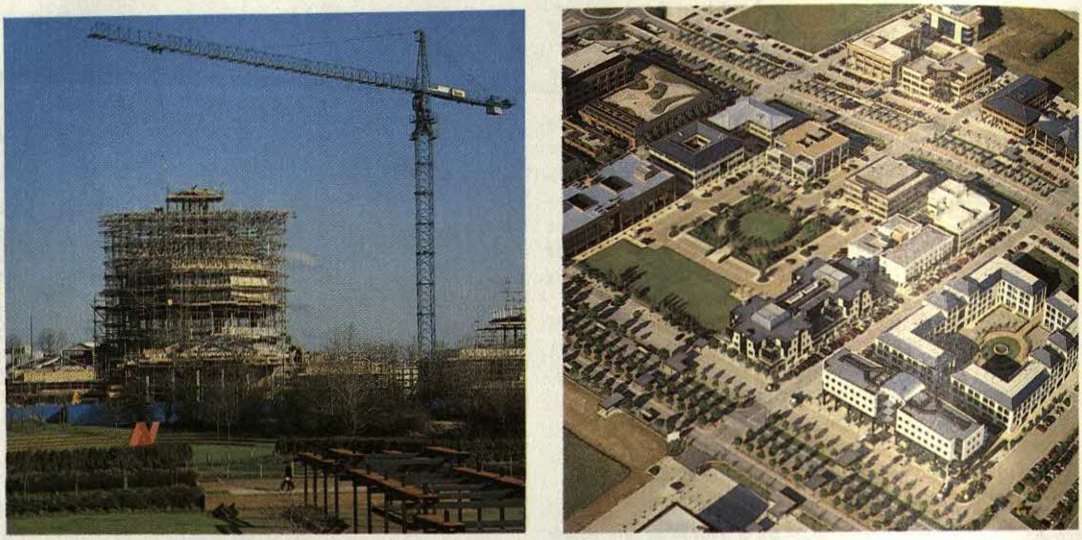
Town planners are still chiefly concerned with the physical layout of communities. But in the mid-1900's, many planners also began dealing with economic and social problems. Today, a town plan may include such proposals as job training programmes for unskilled workers, special schooling programmes for disadvantaged children, and health services for the needy.

Making the plan work

Town planners need both money and authority to carry out their programmes. They get the money from local and national governments. But governments get their money by taxing the people, so the money a town planner uses actually comes—indirectly—from the people. Local and national governments give town planners the authority they need to carry out their plans.

Gaining support for the plan. Strong public opposition can cause a government to refuse to act on proposals of a master plan.

Town planners are likely to gain public support with proposals that capture the imagination of the people. Such proposals include the construction of giant buildings, new civic centres, and elevated car parks and streets. Sometimes a plan gains public support because it includes proposals for solving problems of deep concern to most of the people.



Milton Keynes was designated one of England's new towns in 1967. Based on the existing town of Bletchley, it saw the construction of many new buildings, *left,* which eventually resulted in a modern, planned city, *right.*

Governmental authority. To carry out their plans, town planners must have control over construction and other activities that affect the layout of a community. They rely on the government's power of *eminent domain* and its authority to enforce zoning laws, subdivision regulations, and building and housing codes.

The term *eminent domain* describes a government's right to buy private property—even when the owner does not want to sell it. Town planners often have to resort to this power to get the land they need for major rebuilding projects. If people live on the property, they are relocated to other residences. Governments may also have to resort to compulsory purchase to get the land needed for road-building programmes. See **Eminent domain.**

Zoning laws designate the kinds of buildings permitted in each part of a community. If a zoning law allows only houses and apartment buildings in a certain area, town planners know they can plan that area as completely residential. Zoning laws also allow planners to regulate sizes of plots, heights of buildings, the number and location of parking areas, and the use of signs.

Other regulations control the subdivision and development of large, open areas of land. Private property developers often buy large areas and subdivide them into plots. They either sell the empty plots or construct buildings on the plots before selling them. Subdivision regulations designate the minimum size of plots and the purposes—residential, commercial, or industrial—for which the developers' land can be used. These regulations also govern other aspects of physical layout. For example, they cover the amount of land that must be used for public buildings, schools, and open spaces.

Building new communities

The term *town planning* usually refers to attempts to improve existing communities. But it can also mean the development of entirely new communities by governments and private companies. These communities, called *new cities* and *new towns,* differ from suburbs in at least one important way. Most suburbs are designed as residential communities for people who work in nearby cities. Planners of new towns try to make them fully or partly self-supporting by attracting businesses where the residents can work. Thus, new towns can be built far from existing towns. In the mid-1900's, the Brazilian government built the city of Brasília far from the country's population centre. New cities are extremely costly projects, and Brasília; Chandigarh, India; and Canberra, Australia, are among the few ever completed.

Criticism of town planning

Although most people favour the goals of town planning, some criticize the methods used to achieve those goals. Major criticisms include the high cost and government control of town planning and what opponents feel is a wrong emphasis on certain goals.

High cost is probably the most common criticism of town planning. Critics claim that the cost of carrying out a master plan places too great a burden on taxpayers. They argue that planners try to do too much at one time.

Government control. Some people object to a government's power to force individuals to sell their property and to regulate its use. Some people also object to the town planner's role as a decision maker because the planner is not an elected official.

Wrong emphasis. Some critics complain that town planners care more about beautifying communities and helping businesses than about solving such social problems as overcrowding and pollution. These critics also charge that changes made for a community's physical improvement sometimes increase the social problems.

Reducing criticism. Town planners need the public's support, and so they work to reduce criticism against their methods. More and more towns are scheduling planning projects farther and farther apart to reduce the financial burden on taxpayers. Town planners hope the increased use of advocacy planning—which gives the public a larger role in the planning process—will help reduce criticism.

History of town planning

People have done some town planning ever since the first towns appeared about 3500 B.C. This section traces some of the highlights of town planning. For a detailed description of towns and cities and their development through the ages, see **City**.

Ancient times. People of ancient towns and cities set aside certain areas for meetings, recreation, trade, and worship. Many ancient peoples built walls around their communities to keep invaders out. Groups of public buildings and monuments are among the major examples of town planning in ancient times. Athens and Rome were especially famous for their public buildings and monuments. See **Athens; Rome** (The ancient city).

Historians believe that Hippodamus, an ancient Greek architect, developed the first systematic theories about town planning. His work included plans for the location of roads and buildings in the cities of Miletus and Piraeus.

The Middle Ages. Many peoples built protective walls around their cities during the Middle Ages—from the A.D. 400's to the 1500's. Population growth caused a number of cities to become overcrowded. Some cities solved this problem by knocking down the walls and rebuilding them farther out. Other cities let the walls stand and built new communities nearby.

Religion played a major role in medieval European life and was reflected in the planning of many cities. The main church stood in the centre of the city and was the biggest and most expensive building.

The Renaissance, a period of great artistic development, began near the end of the Middle Ages and lasted into the 1600's. Several leading artists of the Renaissance, including Gian Lorenzo Bernini, Leonardo da Vinci, and Michelangelo, helped beautify cities.

During the Renaissance and for many years afterward, town planners designed parts of cities on a grand scale. They created open spaces to overcome the overcrowding of earlier days. Examples of this trend include the huge plazas in front of the Cathedral of Saint Mark in Venice, Italy, Saint Peter's Church in Vatican City, and the beautiful palace and gardens at Versailles, near Paris. Another example is Georges Eugene Haussmann's plan for Paris in the mid-1800's. Haussmann designed wide boulevards and plazas and helped make Paris one of the world's most beautiful cities.

The Industrial Revolution of the 1700's and early 1800's marked the beginning of the factory system of manufacturing. In Europe and North America, the population of cities increased rapidly as workers left farms to take manufacturing jobs in the cities. Cities became overcrowded, dirty, and noisy. Many people lived in crowded, run-down, unsanitary housing near the factories.

Social reformers began calling on governments to improve city life. They proposed new housing areas with gardens and open spaces and new communities with industry and housing in separate areas. Governments took some steps to regulate the quality of housing and to otherwise improve cities. But the cities continued to grow, and town planning failed to keep pace.

The 1900's. The rapid increase in urban problems during the late 1800's forced governments to take a greater part in town planning. Between 1900 and 1930, many governments established town planning commissions and introduced zoning laws.

The urban population explosion that followed World War II (1939-1945) caused severe housing shortages, more slums, and heavier traffic than ever. Planners had to expand their programmes to provide for new housing projects, parks and recreation areas, and better industrial and commercial districts.

Related articles in ***World Book*** include:

Architecture
Brasília
Burnham, Daniel H.
Canberra
Chandigarh
City
Eminent domain
Housing
Landscape architecture
Le Corbusier
L'Enfant, Pierre C.
New town
Soleri, Paolo
Tapiola

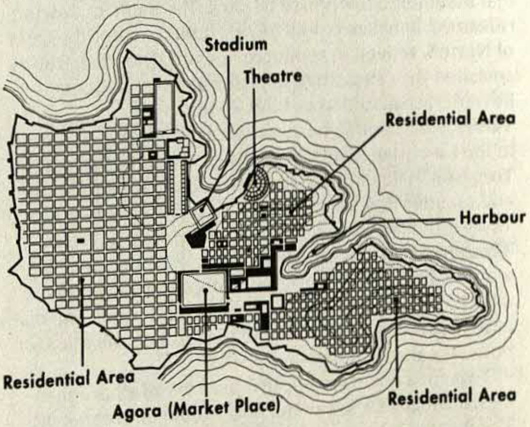
Outline

- **I. The master plan**
  - A. Preparing the plan
  - B. Proposals of the plan
- **II. Making the plan work**
  - A. Gaining support for the plan
  - B. Governmental authority
- **III. Building new communities**
- **IV. Criticism of town planning**
  - A. High cost
  - B. Government control
  - C. Wrong emphasis
  - D. Reducing criticism
- **V. History of town planning**

Questions

What does a master plan for a town or city include?
Who probably developed the first theories about town planning?
What is the power of *eminent domain* ?
Why is public support important to a town planner?
What is *advocacy planning* ?
How do zoning laws help town planners?
What are some criticisms of town planning?
How did the Industrial Revolution increase the need for town planning?

Townes, Charles Hard (1915-), is a United States physicist. In 1951, he explained the basic principles that led to the development of the maser. A *maser*



Miletus, an ancient Greek colony, was one of the first cities to have the regular arrangement of city blocks called the *gridiron pattern.* Hippodamus, the man who planned Miletus, is sometimes called the father of town planning.

is a device that uses the energy of molecules or atoms to amplify radio waves. Townes helped build the first maser in 1953 (see **Maser**). In 1958, Townes and Arthur L. Schawlow proposed the *laser,* a device for amplifying light waves (see **Laser**). For his work, Townes shared the 1964 Nobel Prize for physics with two Soviet scientists who also developed and improved masers.

Townes was born in Greenville, South Carolina, U.S.A.

See also **Basov, Nikolai; Prokhorov, Alexander.**

Towns, Robert (1794-1873), a successful merchant and estate owner, was the first farmer to grow cotton on a large scale in Australia. He was also one of the first to import *kanakas* (labourers from the South Pacific islands). Towns owned estates in Queensland and played a leading part in founding Townsville. Towns was born in Northumberland, England.

Townshend, Viscount (1674-1738), was an English politician and promoter of agricultural reform. Townshend supported a crop-rotation system that used four different crops. His system made farms more productive because it did not leave fields fallow (see **Agriculture** [Improved crop-growing methods]).

Townsville (pop. 87,268) is a port in tropical Queensland, on the east coast of Australia. It lies on the Ross River and Cleveland Bay, almost 1,340 kilometres north of Brisbane. It is the largest city in the tropics of Australia. It is the economic centre of a rich pastoral, agricultural, and mining area. For location, see **Queensland** (map).

Townsville is an administrative, commercial, and industrial centre. It has railway workshops, meatworks, cement works, a nickel treatment plant, and a copper refinery. The city is served by air, rail, and road transport.

Townsville was founded in 1864. It was named after the merchant and estate owner Robert Towns, who played a leading role in founding the city.

Towton, Battle of (1461), was a decisive battle of the Wars of the Roses. Edward, Earl of March, had himself proclaimed King Edward IV of England soon after the death of his father, Richard of York, at the Battle of Wakefield. Henry VI and his wife, Queen Margaret, remained at their headquarters in York, England, while the Duke of Somerset commanded the Lancastrian army that assembled to oppose Edward. The Battle of Towton remained in balance until a Yorkist force under the Duke of Norfolk arrived to reinforce Edward. The fresh troops smashed the Lancastrian left flank and won a victory for Edward. See also **Wars of the Roses.**

Towy, also spelt *Tywi,* is a river in South Wales. It rises in the Cambrian Mountains, about 13 kilometres east of Tregaron. It flows south and west about 105 kilometres and empties into Carmarthen Bay, in the Irish Sea. The Towy is the longest river that flows entirely in Wales.

Toxaemia of pregnancy is a disease that attacks women during the later months of pregnancy or just after giving birth. It is also called *preeclampsia.* The disease may result in the death of the mother, the fetus, or both. Its cause is unknown.

Toxaemia occurs in about 5 per cent of all pregnancies. It usually strikes in the final month of pregnancy. The disease is characterized by a rise in blood pressure, excessive protein in the urine, and body swelling. Unless treated, toxaemia may progress to *eclampsia,* a life-threatening condition in which the victim suffers convulsions. Eclampsia is usually preceded by such symptoms as headache, severe pain over the liver, and extremely high blood pressure. But convulsions may appear without warning. The victim may also suffer other major complications, including loss of kidney function, liver disease, and *cerebral haemorrhage* (bleeding in the brain). Deaths from toxaemia most often occur in developing countries. In industrial countries, early diagnosis and treatment usually prevent severe cases.

Toxaemia affects the fetus by restricting circulation of the mother's blood to the *placenta,* the organ that provides the fetus with food and nourishment. As a result, the fetus may not develop normally and it may die.

Treatment of toxaemia consists of hospitalizing the victim and controlling her blood pressure. If symptoms of eclampsia appear, doctors administer drugs to prevent convulsions. They also end the pregnancy, either by removing the fetus surgically or by using drugs to bring about early delivery. After the pregnancy ends, the victim usually recovers rapidly.

Toxic shock syndrome, or *TSS,* is a rare disease that most frequently occurs in young women who are having a menstrual period. Symptoms include a high temperature, vomiting, diarrhoea, low blood pressure, and a sunburnlike rash.

TSS is caused by a bacterium called *Staphylococcus aureus,* which can produce infection anywhere on or inside the body. Scientists suspect the bacteria release a *toxin* (poison) that spreads through the body, probably by way of the bloodstream, and causes TSS.

Fewer than one-thousandth of 1 per cent of all menstruating women are likely to develop TSS each year. Most victims are teenagers and women in their twenties who use a *tampon*—a roll of absorbent material inserted into the vagina—during the menstrual period. Doctors do not know why women who wear tampons run a greater risk of developing TSS than those who wear sanitary towels. Public health doctors have not advised women to stop using tampons, but they do recommend that tampon-users recognize the symptoms of TSS. A woman who develops symptoms should remove the tampon and call a doctor immediately.

Doctors treat TSS with antibiotics and with fluids given through a vein. A female patient not treated with antibiotics may become ill again during her next menstrual period. Most patients recover and have no further problems. But some lose their hair, fingernails, or toenails. About 4 per cent of TSS cases are fatal.

Toxic wastes. See **Hazardous wastes.**

Toxin is a poison produced by a living organism. Toxins may cause many diseases and even death. Some toxins remain inside the organism that produces them. They are called *endotoxins.* They cause poisoning only when the organism is broken up and the poison escapes. Other toxins, called *exotoxins,* are secreted into the substance surrounding the organism.

Bacteria (small organisms) that infect the human body may produce toxins that cause diphtheria, tetanus (lockjaw), gas gangrene, and scarlet fever. Some bacteria and fungi secrete toxins into the foods in which they grow. Such diseases as botulism, ergotism, and alimentary toxic aleukia may result if food with toxins is eaten.

Some tropical fish produce toxins that remain in their bodies. These toxins do not harm the fish, but they can cause illness or death to a person who eats the fish. The venoms of poisonous snakes, spiders, and insects are toxins. Doctors prescribe *antitoxins* to fight toxins (see **Antitoxin**).

See also **Serum; Disease** (**Bacterial diseases**).

Toxoplasmosis is a common disease characterized by enlargement of lymph nodes, usually in the neck region. Other symptoms may include fever and fatigue. In rare cases, toxoplasmosis can severely infect the internal organs. It can be fatal if left untreated.

Toxoplasmosis is caused by a *protozoan* (single-celled organism) often found in cats. The scientific name for this protozoan is *Toxoplasma gondii.* People become infected with *T. gondii* by eating food contaminated by cat *faeces* (solid body waste) or by eating the uncooked meat of infected animals, such as pigs and sheep.

Symptoms of the disease can last several weeks or months. However, *T. gondii* stays in the body in a dormant state. Usually, it remains dormant for the person's entire life. But if the person's immune system is weakened by cancer or by AIDS, or other infections, *T. gondii* may become reactivated. The reactivation infection most commonly occurs in the brain and can be life-threatening. Such cases are treated with an antimalaria drug in combination with sulpha drugs.

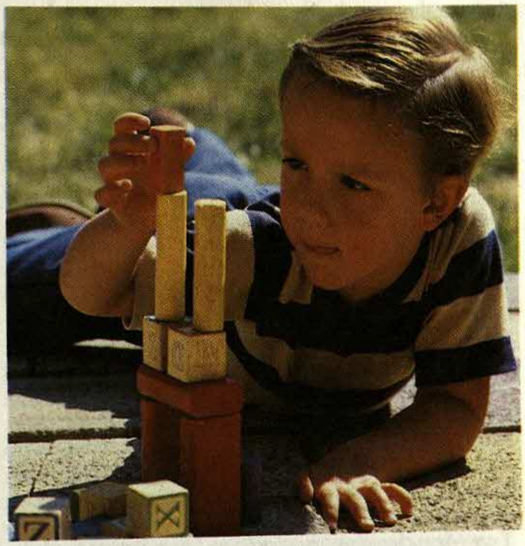
If a woman becomes infected with *T. gondii* during her first three months of pregnancy, the infection can spread to her *fetus* (unborn baby). Such infection can cause birth defects or the death of the fetus. It also can cause an eye infection that may lead to blindness later in life.

Toy is an object children can use as a plaything. Children throughout the world play with similar toys, such as balls, dolls, games, and puzzles. Since ancient times, toys have played an important role in children's lives. Some toys enable children to have fun while learning about the world around them. Games can help teach children to get along with others. Toys may also help them learn and develop special skills.

Manufacturers make thousands of different toys. A child plays with toys of increasing sophistication at each stage of his or her development. Toys can be divided into three main groups: (1) toys for infants, (2) toys for early childhood, and (3) toys for late childhood.

Toys for infants. An infant's first toys are often soft musical toys and *mobiles* (colourful, moving structures hung above a crib). These toys begin to stimulate vision and hearing. Later, when babies can hold or grasp toys on their own, they play with rattles, plastic blocks, and stuffed animals. Unbreakable mirrors help infants recognize themselves. As they begin to walk, youngsters like to play with push toys that help them balance. They also push themselves along with their feet on cars and other wheeled riding toys. Infants are mentally stimulated by simple puzzles and picture books.

Toys for early childhood. After children learn to walk and run, they become more interested in exploring the world around them. In these years, from ages 2 to 6, children need more physical play to develop the muscles in their arms and legs. Play with toys such as large building blocks and wagons helps strengthen these muscles.



Stacking blocks of various shapes helps this child learn to balance objects and to make many kinds of structures. Youngsters like to use their imagination to arrange blocks in creative ways.

Children use their imagination when they play with small plastic people or farms. Other toys help children develop mentally by encouraging them to count, speak, read, tell the time, and work at a table or desk. These toys include plastic letters and numbers, toy telephones, picture story books, and pegboards. Puzzles challenge children to take things apart and put them back together. At this time, children often learn about emotions and caring through play with special dolls or stuffed animals.

Toys for late childhood. In late childhood, from about age 6 to 12, toys become part of more elaborate imaginative play. In playing with a doll or dolls, children pretend they are parents and use pushchairs, doll beds, and feeding equipment. Children also enjoy playing with action figures, such as robots, soldiers, and space aliens. In these years, children may learn to use clay, paints, and pastels as their artistic ability grows. Board and computer games help develop a child's mind. In many of these games, children must plan their own strategies and also guess what moves their opponents will make.

Near the end of childhood, boys and girls enjoy building model cars and ships and working with hobby kits. Kits, such as woodburning or embroidery, help develop discipline and patience. Children who like science may spend hours with chemistry sets or microscopes. These activities may persist as adult hobbies.

History. Children have played with toys for thousands of years. In ancient Africa, children enjoyed balls, toy animals, and pull toys. Children of ancient Greece and Rome had fun with boats, carts, hoops, and tops. During the Middle Ages in Europe, popular toys included clay marbles, rattles, and puppets.

Before the development of large toy factories, parents or craftworkers made toys. By the 1800's, children in many countries were playing with both homemade toys and commercially produced toys.

Governments in many countries have passed laws that enable them to recall or prohibit the sale of toys that are shown to be harmful. Such toys may contain poisonous substances, catch fire easily, have loose parts a child can swallow, or have unprotected points or sharp edges.

Related articles in *World Book* include:

Aeroplane, Model
Car, Model
Doll
Dolls' house
Frisbee
Hobby
Kaleidoscope
Kite
Play
Puppet
Railway, Model
Rocket, Model
Ship, Model
Skateboard
Top
Yo-yo

Toy dog is the name of a group of small dogs. Many are relatives of larger dogs. For example, the toy poodle is a tiny poodle. Other toys, such as the Chihuahua, are separate breeds. The recognized toy breeds include the affenpinscher, Brussels griffon, Chihuahua, English toy terrier, Italian greyhound, Japanese chin, Maltese, miniature pinscher, papillon, Pekingese, Pomeranian, pug, shih tzu, silky terrier, and Yorkshire terrier. *World Book* has separate articles for each of the breeds listed here. See also **Dog** (pictures: Toy dogs).

Toy Manchester terrier. See **Manchester terrier.**

Toynbee is the family name of two men, uncle and nephew, who contributed to sociology and our understanding of history.

Arnold Toynbee (1852-1883) was interested in the problems caused by poverty. An enthusiastic social reformer, he lived in a shabby dwelling in Whitechapel, a London slum district. He worked for the improvement of the poor, changes in the poor laws, and freedom of work. He urged prevention of waste by an equalization of supply and demand. He thought the church should work for social progress, and taught that imitation of Jesus' life of service to humanity was true Christianity. His best-known book was *The Industrial Revolution* (1884).

Toynbee was born in London, and was educated at Oxford University. His hard work to improve conditions ruined his health. Shortly after his death, Toynbee Hall, the first settlement house in the world, was set up in Whitechapel to help the poor.

Arnold Joseph Toynbee (1889-1975) was a famous historian. His outline of civilizations, *A Study of History,* was published in 12 volumes from 1934 to 1961. Toynbee divided world history into 26 civilizations, and traced their rise, decline, and fall. He declared that the one hope for the survival of Western civilization lies in a rebirth of the Christian spirit.

Toynbee's original and bold approach to world history, that of "an ancient historian, looking at the Western World from the outside," had a wide appeal. A two-volume abridgment of his great work sold widely in Europe and the United States. His writings include a number of volumes dealing with social-historical problems, such as *Nationality and the War* (1915), *Civilization on Trial* (1948), and *The World and the West* (1953).

Toynbee was born in London. He studied at Balliol College, Oxford, and at the British Archaeological School in Athens, Greece. Toynbee became a professor of international history at the University of London in 1925. See also **Civilization** (Why civilizations rise and fall).

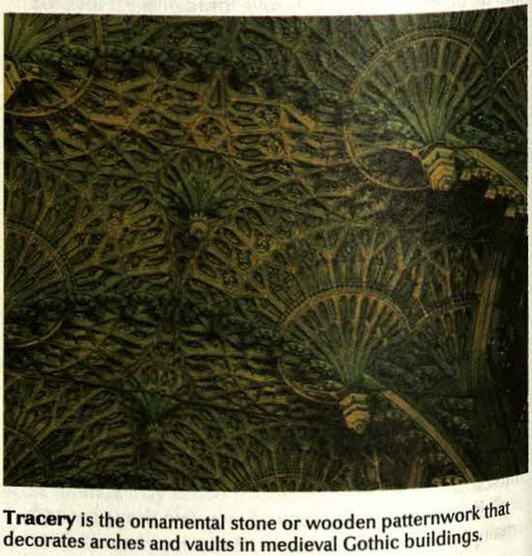
Trace elements are minerals needed in small amounts by plants, animals, and human beings. Such major elements as calcium, carbon, chlorine, hydrogen, magnesium, nitrogen, oxygen, phosphorus, potassium, sodium, and sulphur are part of the makeup of all living things. The trace elements are also necessary to life. Scientists know the uses of only a few of the trace elements. However, scientists know that trace elements are necessary for the work of such vital bodily compounds as enzymes and hormones (see **Enzyme; Hormone**).

The trace elements include chromium, cobalt, copper, fluorine, iodine, iron, manganese, molybdenum, selenium, and zinc. The body needs copper so it can use iron to build haemoglobin, an important part of red blood cells. Cobalt, contained in vitamin B_{12}, protects against a blood disease called *pernicious anaemia.* Only 0.000002 gram of this vitamin each day keeps people with pernicious anaemia healthy. Iodine is needed to form the hormone *thyroxine.* A lack of iodine in the diet results in *goitre,* a disease characterized by excessive growth of the thyroid gland. Manganese and zinc are required for the normal action of certain enzymes. Without these two minerals, certain reactions in the body cells would stop. Human beings and all animals need the same trace elements, but plants have different requirements. For example, plants do not need iodine or fluorine. Human beings get the required trace elements from food.

See also **Nutrition.**

Tracery, in architecture, originally was the framework of light ornamental stone bars dividing a large window into smaller areas so that the stained glass could be easily placed and supported. Usually tracery took the form of tall, narrow, arched divisions below, with circles, cusps, and other shapes filling the upper part of the window. Later, these shapes were used to decorate wall panels, buttresses, vaulting, and furniture.

Builders first used tracery in the late 1100's, when church windows grew too large to be glazed in one unbroken area. It developed rapidly in delicacy and became a marked feature of nearly all Gothic architecture. The earliest tracery was called *plate* tracery, because the upper circles were pierced through a plate of stone in



Tracery is the ornamental stone or wooden patternwork that decorates arches and vaults in medieval Gothic buildings.

the upper part of the main window arch. *Geometric* tracery, a complete pattern of thin stone bars, later replaced this pierced "plate." In it, all the openings between the bars are simple geometric forms. Still later, *flowing* and *flamboyant* tracery was used, so called because of its flowing and swaying flamelike shapes. In the late 1300's and the 1400's in England, *perpendicular* tracery was the rule. In it, the vertical bars between the lower openings are carried up the whole height of the window, making small vertical panels.

Trachea, also called *windpipe,* is the tube that carries air between the lungs and the upper respiratory passages. A human trachea is about 13 centimetres long and just less than 2.5 centimetres in diameter. About half of its length is inside the chest and the rest is in the neck. The trachea is held open by 16 to 20 incomplete rings of cartilage. These C-shaped cartilages form the hard ridges in the front of the neck just below the *Adam's apple.*

The lower end of the trachea divides into two *bronchi* (tubes) that carry air into the lungs. At the top of the trachea is the Adam's apple. This bump in the neck is formed by the *larynx* (voice box). Air that passes over the vocal cords in the larynx causes them to vibrate and to produce the sound used to speak.

Air is breathed into the larynx and trachea through the *pharynx,* the space at the back of the throat where the passages of the nose and mouth meet. The *epiglottis,* a leaf-shaped structure in the pharynx, closes the opening into the larynx during swallowing to prevent food from entering the larynx and trachea.

Related articles in *World Book.* See the Trans-Vision three-dimensional picture with **Human body.** See also **Larynx; Lung; Pharynx; Throat.**

Trachoma is a contagious eye disease caused by a form of *Chlamydia trachomatis* bacteria. Trachoma is relatively rare in many industrialized countries. But in developing countries in warm parts of the world, trachoma is still the leading cause of blindness. It affects the *conjunctiva* (membrane of the eyeball and lids) and *cornea,* the window of the eye (see **Eye** [Parts of the eye]). Symptoms of conjunctivitis develop and the disease may last for years (see **Conjunctivitis**).

Doctors must report cases of trachoma because the disease spreads easily. People in affected areas are warned not to share towels, nor to rub their eyes with unwashed hands. Trachoma can be treated effectively with antibiotics. Severe cases may require an operation to repair deformed eyelids or to replace damaged corneas.

Track. See **Railway** (Tracks).

Track and field. See **Athletics.**

Tracking. See **Space travel** (Communications with the earth; Artificial satellites).

Tractarians were leaders of the Oxford Movement in the Church of England in the 1830's. The movement sought to restore to the Church of England an awareness of its Catholic faith and spiritual independence. The Tractarians published a series of *Tracts for the Times* to emphasize important aspects of the Church's teaching.

John Henry Newman wrote the first tract, which was published in 1833. John Keble, Edward Pusey, and others also wrote tracts. The last tract, Tract 90, published in 1841, provoked much controversy.

See also **Keble, John; Newman, John Henry Cardinal; Pusey, Edward Bouverie.**

Tractor is a machine that pulls or pushes a tool or a machine over land. Tractors provide the chief source of power on most farms. They are also used for industrial and military purposes, for logging, road construction, and snow clearance. Tractors have either petrol or diesel engines (see **Diesel engine; Petrol engine**).

Parts of a tractor. The modern tractor has several built-in features that enable it to provide power for other farm machines. These features include the drawbar, a hydraulic system, and a power take-off.

The drawbar is a device for fastening equipment to the tractor for pulling. The drawbar enables a tractor to pull such equipment as ploughs, wagons, harrows, combine harvesters, and hay balers.

The hydraulic system controls the working position of implements hitched to or mounted onto the tractor. An engine-driven hydraulic pump and cylinder provide power to raise and lower these implements. Many rear-wheel-drive tractors have hydraulic systems with a mechanism that shifts weight from the front to the rear wheels of the tractor. The weight shift increases traction for pulling mounted implements.

The power take-off, or *PTO,* provides power for machines that are either mounted on or pulled by the tractor. The coupling device between the PTO and the equipment usually consists of two universal joints, one on each end of a telescoping shaft. The flexible action of the joints and the telescoping action of the shaft allows sharp turning and movement over rough surfaces without harming the power system. The PTO drives the moving parts of mowing machines, hay balers, combines, potato diggers, and spray pumps.

Types of tractors. There are two major types of tractors: the wheel tractor and the tracklayer tractor, known as a *crawler* or *caterpillar.*

Wheel tractors make up the majority of farm tractors in most countries. Many farmers use an *all-purpose* tractor because it does a variety of jobs, such as planting, cultivating, and harvesting. It has high rear wheels. It has either one small front wheel or two placed close to-

A general-purpose tractor performs many jobs on a farm, including ploughing, planting, fertilizing, and cultivating.

A crawler tractor, sometimes called a *caterpillar tractor,* does such work as moving earth for construction jobs, *above.*

gether or two front wheels spaced the same as the rear wheels. The spacing of the wheels enables the tractor to be driven between rows of crops. Wheel tractors may have either two-wheel or four-wheel drive. Two-wheel-drive models range in weight from about 1,400 kilograms to more than 9,000 kilograms. Four-wheel-drive tractors may weigh as much as 27,000 kilograms. The demand for larger tractors has increased as the average size of farms has increased.

Crawler tractors are driven on two endless tracks. They are steered by stopping or slowing one of the tracks. Crawler tractors are used for heavy jobs, for land clearing, and for work on soft or rugged land. The smallest crawlers weigh about 1,720 kilograms. The largest of these tractors weigh more than 32,000 kilograms.

History. Tractors were first used during the 1870's. These tractors, called *traction engines,* were large, four-wheeled machines driven by steam. They provided enough power to pull as many as 40 ploughs, but they were too awkward to be practical. Smaller machines with internal-combustion engines soon replaced them. But the new machine had only a paraffin-burning engine mounted on a four-wheeled frame. Later, paraffin or petrol engines were built as part of the tractor frame. The tractors could do almost all the field work, but were too low to pull a cultivator through tall crops. Then, in the 1920's, the all-purpose tractor was developed.

Early manufacturing companies usually made only one tractor model or size. But modern companies make a complete line. Modern tractors have both speed and power, and are easy to operate. Most have power steering and power brakes. Many also have enclosed cabs with heating and air-conditioning systems and special structures that protect the operator if the tractor accidentally turns over. There are about 25.5 million farm tractors in use throughout the world.

See also **Agriculture** (picture: An early petrol-powered tractor); **Bulldozer.**

Tracy, Spencer (1900-1967), was an American film actor. He became famous for his roles as a strong man of action and conviction in such films as *Bad Day at Black Rock* (1955) and *The Old Man and the Sea* (1958). He also won fame as a sophisticated comedian in several films, including *Woman of the Year* (1942) and *Father of the Bride* (1950). Tracy won Academy Awards for his performances in *Captains Courageous* (1937) and *Boys Town* (1938). He received seven other Academy Award nominations.

Spencer Tracy

Tracy was born in Milwaukee, Wisconsin, U.S.A. He made his stage debut in 1922. A 1930 stage performance led Tracy to a film contract, and he made his film debut that year in *Up the River. The Power and the Glory* (1933) established him as a star. Tracy made more than 70 films, including *State of the Union* (1948), *Adam's Rib* (1949), *Inherit the Wind* (1960), *Judgment at Nuremberg* (1961), and *Guess Who's Coming to Dinner* (1967), which was his last film.

Trade is buying and selling goods and services. Trade occurs because people need and want things that others produce or services others perform.

People must have such necessities as food, clothing, and shelter. They also want many other things that make life convenient and pleasant. They want such goods as cars, books, and television sets. They want such services as haircuts, cinemas and theatres, and bus rides. As individuals, people cannot produce all the goods and services they want. Instead, they receive money for the goods and services they produce for others. They use the money to buy the things they want but do not produce.

Trade that takes place within a single country is called *domestic trade. International trade* is the exchange of goods and services between nations. It is also called *world trade* or *foreign trade.* For detailed information on international trade, see **International trade.**

Trade has contributed greatly to the advance of civilization. As merchants travelled from region to region, they helped spread civilized ways of life. These traders carried the ideas and inventions of various cultures over the routes of commerce. The mixing of civilized cultures was an important development in world history.

Trade and specialization

Trade is vital both in industrial and in developing nations. The economic systems established in most countries have a high degree of *specialization,* or *division of labour.*

Specialization means that each worker concentrates on one job, such as being a farmer, mechanic, or doctor. Factories concentrate on making one product, such as washing machines, canned soup, or shirts. Countries, cities, and regions also concentrate on producing certain goods and services. For example, Australia specializes in raising livestock, and Japan in manufacturing industrial products.

Specialization makes trade necessary. Because people do not produce everything they need themselves, they become dependent on others. They sell their labour or products for money, and use the money to buy other goods and services that they need.

Trade helps people enjoy a higher standard of living.

People can obtain more goods and services at lower cost through specialization and exchange. If workers concentrate on the job they are best fitted to perform, they can produce more than if they try to do several different jobs. If factories specialize, they can use mass production methods and complicated machines and tools to produce more (see **Mass production**). If regions specialize in what they produce, they can use their most plentiful resources. They can build up a supply of skilled labour and specialized *capital* (goods used to produce other goods).

Carrying on trade

The use of money. To make trading easier, people have developed *monetary systems.* Large-scale trade is simplest if money is used as a medium of exchange. Without money, people have to exchange certain goods and services directly for other goods and services. This system of trade is called *barter.* Using barter, a banana grower who wanted a horse would have to find a horse owner who wanted some bananas. The two traders would then have to agree on how many bananas a horse was worth.

People accept money for things they want to sell because they know it will be accepted by others in exchange for the things they want to buy. The amount of money exchanged for a particular product is the *price* of that product. See **Money** (How money developed); **Price.**

The use of markets. Trade takes place in *markets.* In earlier days, it was usual for buyers and sellers to meet and bargain with one another in markets. For example, farmers came to town with their produce on market day. The townspeople shopped around the market and negotiated directly with the seller. This still happens in some countries, but today most trade is more complicated.

Often, producers and consumers do not deal directly with one another. Instead, goods are passed on from producers to consumers through people called *middlemen.*

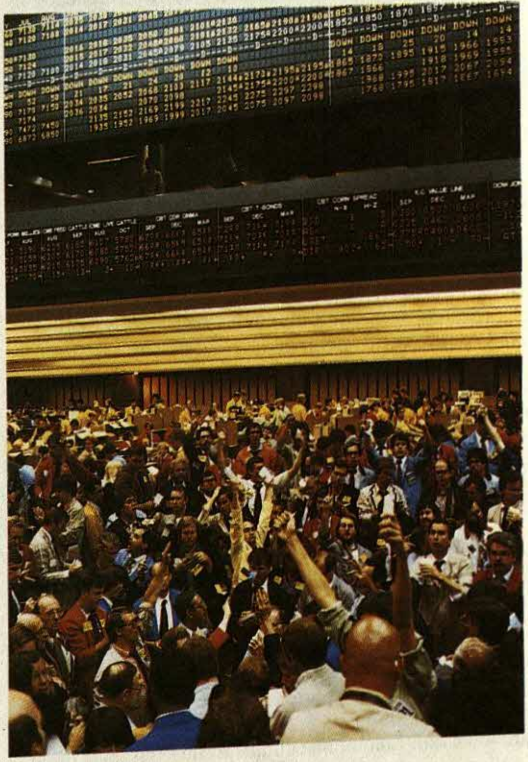
Two kinds of middlemen are *wholesalers* and *retailers.* Wholesalers buy goods from producers and sell them mainly to other business firms. For example, a wholesaler of vegetables buys large amounts of vegetables from the growers and then sells them in bulk to grocers. This kind of trade is called *wholesale trade.* The grocers sell the vegetables to customers who eat them. This type of trade in which merchants sell goods mainly to the final consumer is called *retail trade.* See **Marketing.**

It is no longer necessary for buyers and sellers to meet face-to-face. Goods and services can be bought and sold by mail, telephone, or electronic means. Often,

Carrying on trade Trade takes place because people need or want the things that other people produce or can do. Trade may be carried on in a number of ways. The illustrations below show trade at local markets, between nations, and at organized markets known as commodity exchanges.

A local market in Morocco

A freight dock in New Jersey, U.S.A.



A commodity exchange in Chicago

buyers and sellers do not even see the product being traded. They transact their business on the basis of description or sample. For example, a buyer of fabrics will usually examine a small *swatch* (sample) of cloth before making a purchase. Cotton, wheat, and many other farm products are classified by grade. Buyers know exactly what they will get if they specify a particular grade, such as "Number 2 hard ordinary wheat." Agricultural goods are often traded at organized markets called *commodity exchanges* (see **Commodity exchange**).

The geographical extent of trade varies widely. In some cases, the buyers and sellers are from all parts of the world. Trade in such basic foods and raw materials as coffee, sugar, wheat, copper, oil, and rubber is international in scope. For example, the United States is a leading producer of wheat. It sells large amounts of wheat to India, Pakistan, Japan, Brazil, the Netherlands, and many other countries.

Trade in other products may be conducted on a national, regional, or local basis. For example, the market for woollen goods in India is concentrated in the north of the country, where it snows in the winter.

In earlier days, local trade was much more important than it is today. This was partly because transportation facilities were limited and goods could not be moved on a large scale. Also, perishable food could not be preserved for very long. Perishable items had to be consumed near their place of production. But technological advances have removed these trade barriers. Trains, trucks, aeroplanes, and pipelines make it possible to move large quantities of goods easily and cheaply. Vegetables, meat, and other perishables can be refrigerated or frozen and shipped all over the world. Even flowers can be flown by aeroplanes to distant markets.

Also in earlier days, people's tastes and preferences varied more from one locality to another. Today, mass advertising in magazines and newspapers and on radio and television persuades people of many different nationalities to use the same products. Millions of people drink the same kinds of soft drinks, use the same brands of detergents, drive the same makes of cars, and wear the same kinds of clothes and shoes. Thus, technological advances have created international markets, and international trade has taken the place of much purely local trade.

Trade in most non-Communist countries is carried out mainly by private persons and businesses. Government plays a less important role than do private individuals and groups, and is more important as a buyer than as a seller. The sellers of goods range from the giant motor car manufacturers, which sell millions of cars and trucks each year, to small shops that sell such goods as bakery products or flowers.

Large amounts of goods and services are purchased by individual consumers, who buy such things as dresses, transistor radios, food, and haircuts. Businesses buy the raw materials and capital equipment they need for production from other businesses. Governments also buy many goods and services, for example, the services of members of the armed forces.

The way in which trade is organized and carried on in a particular country is that country's economic system. In most non-Communist countries this system is often called *capitalism, free enterprise,* or *private enterprise* (see **Capitalism**). Trade—buying and selling goods and services in the market—is an essential part of a free economy. In the free market, consumers help determine prices and thus what will be produced. Their willingness to pay for what they want indicates to producers what ought to be produced. In China and other countries with *centrally planned economies,* government planners make the basic economic decisions both about what will be produced and about the prices of the products.

The development of trade

Early trade. For thousands of years, families produced most of the things they needed themselves. They grew or hunted their own food, made their own simple tools and utensils, built their own houses, and made their own clothes. Later, people learned that they could have more and better goods and services by specializing and trading with others. As civilization advanced, exchanges became so common that some individuals did nothing but conduct trade. These people became known as *merchants.*

The most famous early land merchants were the Babylonians and, later, the Arabs. These traders travelled on foot or rode donkeys or camels. The Phoenicians were the chief sea traders of ancient times.

Trade was very important during the hundreds of years the Roman Empire ruled much of the world. Roman ships brought tin from Britain, and slaves, cloth, and gems from the Orient. For more than 500 years after the fall of the Roman Empire in A.D. 476, little international trade took place.

The expansion of trade began in the 1100's and 1200's, largely because of increased contacts between people. The crusades encouraged European trade with the Middle East (see **Crusades**). Marco Polo and other European merchants made the long trip to the Far East to trade for Chinese goods (see **Polo, Marco**). Italians in Genoa, Pisa, and Venice built great fleets of ships to carry goods from country to country.

A great period of overseas exploration began in the 1400's. Trade routes between Europe and Africa, India, and Southeast Asia were established as a result of the explorations. In the 1500's and 1600's, private groups formed companies, usually with government approval, to trade in new areas.

Trade today affects the lives of most people. Improved transportation permits trade between all parts of the world. Through specialization, more and better goods and services are produced. Increased production has led to higher incomes, enabling people to buy more of these goods and services.

Related articles in ***World Book.*** See the trade section of various country articles, such as **Italy** (Trade). See also:

Balance of payments
Bank
Barter
Bazaar
Bill of exchange
Business
Colonialism
Common market
Contraband
Customs union
European Union
Exploration
Exports and imports
Fair
Fair-trade laws
Free trade
Indian, American (Trade)
Industry
International trade
Marketing
Mercantilism
Money
Stock exchange
Tariff
Trade association
Trade route
Trading post

Trade, Board of. See Commodity exchange.

Trade association is a nonprofit organization that represents a group of business firms. Businesses join their associations voluntarily and manage them cooperatively. The companies in a trade association work together to accomplish goals that no single firm could reach by itself.

A trade association may have only a few members, as in the ironmaking and steelmaking industry. Or it may have thousands of members, as in an association of retail grocers. The size of the trade association's membership has little to do with the effectiveness of the organization. It is more important that the association include most of the companies in the industry. In the United States, for example, about 3,600 trade associations operate on the national level.

Trade association activities include promoting business for the industry; encouraging ethical practices in the industry; cooperating with other organizations; and holding conventions. Such associations also work to obtain good relations with the government, the industry's employees, and the general public.

In many countries, trade associations sponsor industrial research. This research helps improve the quality of goods or services sold by individual firms. Setting industry standardization is another important trade association activity. By obtaining agreements among firms, the trade association sets standards of size and quality for articles and services.

A trade association acts as a source of information about its industry. It may issue bulletins on business trends and provide advisory services and statistical information. It may also investigate complaints against its members. Some publish magazines that are distributed to the public. Trade associations date back to the *guilds* formed in Europe during the Middle Ages.

Related articles in ***World Book*** include:

Chamber of commerce
Guilds

Trade publication is a periodical devoted to a specific professional, business, industrial, or trade field. Most are weekly or monthly magazines, but there are a number of newspaper-style weeklies, as well as some dailies. These publications carry news items and articles designed to inform the reader about the particular trade or industry. See also **Advertising** (Magazines); **Magazine** (Kinds).

Trade route is a route along which goods are transported from one area to another. In early times, trade routes brought the luxuries of the Orient into western Europe. Later, these routes allowed various countries to exchange raw materials and manufactured goods. Commerce gave rise to great cities along the routes. Trade routes have also increased contacts between peoples and resulted in an exchange of ideas and ways of doing things. Trade routes greatly affected the entire growth of civilization. Trade with Muslims of the Middle East brought new goods and new knowledge to Europe during the Middle Ages. The Italian trader Marco Polo's famous travels revealed knowledge of China and the Mongol Empire.

Early trade routes existed among primitive peoples. They expanded greatly as people became more civilized. Early Sumerians travelled by caravans throughout western Asia to the Mediterranean Sea. The Phoenicians traded by water routes that connected Egypt, Greece, Asia Minor, Italy, and the British Isles.

Rich commerce flowed from eastern Asia to Europe by three major routes. The northern route, or Great Silk Route, cut from China across central Asia to the Caspian and Black seas, ending at Byzantium (now Istanbul). But, as this overland route was expensive and dangerous, much of the silk commerce travelled by the middle route. It passed through the Persian Gulf and Euphrates Valley and ended either on the Black Sea coast or in such Syrian cities as Damascus. The southern route, by water, led from China around the southern tip of India, up the Red Sea, and overland to the Nile and northern Egypt. Merchants used the southern route to carry spices and pearls from Ceylon (now Sri Lanka); cotton, spices, precious stones, and drugs from India; and cinnamon and incense from Arabia.

Merchants of the Roman Empire carried on a vast amount of trade throughout the then known world. After the fall of the West Roman Empire, Roman roads were completed and extended. They crossed the Alps, and branched out into Spain, France, and Germany. Water transportation also played a large part in European trading. Early traders shipped goods on the Seine, Rhine, and Danube rivers in western Europe, and on the Volga and Don in eastern Europe. Through such French seaports as Bordeaux and Nantes on the Atlantic Ocean, these traders exchanged the wine, grain, and honey of France for metals from Britain, and oil and lead from Spain.

Medieval routes. Cities trading with the eastern Mediterranean, such as Venice and Genoa, built powerful commercial empires. Ships brought goods from eastern Asia. Then Italian fleets carried the products to ports in Spain, England, and Flanders. Other goods crossed overland through Italy and across the Alps to France and to German cities along the Rhine and Danube. Merchants of the Hanseatic League bought these goods in Flanders or Germany, and carried them, along with their own products, to England, the Baltic countries, Poland, and Russia.

The search for new routes led to a great age of exploration and discovery. During the 1400's, European nations began to search for new routes to eastern Asia to avoid the expensive tolls and the many hazards of the long journey from the Orient. In addition, Italian city-states had a complete trade monopoly, which resulted in high prices and low profits to northern European merchants.

The voyages of Columbus and other European explorers opened people's eyes to a whole new world. Many new all-water trade routes grew up. Nations set up trading companies to govern and control trade. The Portuguese first developed trade between India and the East Indies and Europe. The Spanish, Dutch, French, and English followed. Their commercial empires led to colonial empires.

Today's trade routes are almost numberless, and cover the entire world. Roads and networks of railways cover continents. Aeroplanes have connected distant points on the globe. Ships carry goods on the world's seas and waterways.

See also **Exploration; Trade; Colonial life in America** (maps: Colonial trade routes); **Colonialism.**

Britain's Trades Union Congress (TUC) holds a large meeting, called a *congress,* each September. Each trade union belonging to the TUC is entitled to send representatives to the congress. The TUC, founded in 1868, is the oldest trade union centre in the world.

Trade unions are organizations of workers that seek to improve their members' pay and working conditions. They do this by negotiating with representatives of the workers' employer in a procedure called *collective bargaining.* Unions also promote better health and safety standards and staff training, as well as seeking other benefits for their members such as discount on goods purchased and the provision of crèche facilities for working mothers. In most countries, trade unions are legal, and are allowed to organize and recruit members. However, government laws regulate trade union activities in many democratic countries. In a few countries, such as the Soviet Union, free trade unions are traditionally not permitted.

In countries where trade unions are legal, no company can dismiss an employee for being a union member. Leading union officials and members of governing executive committees are elected by secret ballot of the union members.

In many countries, trade unions engage in politics. Unions have generally supported socialist policies as a way of improving social conditions. Some political parties, such as the British Labour Party, have close links with the trade union movement.

In the United Kingdom, trade unions may sponsor members of Parliament (MP's). A union may help to pay MP's election expenses, and make them a small annual payment. Many British Labour MP's are sponsored by unions.

What unions do

Trade unions in Eastern Europe, South America, and South Africa have often led political protest and change. Governments have tried to limit trade union activity by passing restrictive laws, by banning unions altogether, or by making the unions instruments of government policy. In South Africa, unions of mineworkers and other labour groups opposed the white government's *apartheid* (racial segregation) policy (see **Apartheid**). In Poland, the Solidarity trade union emerged in the 1980's as a democratic reform movement, which challenged the Communist government (see **Poland**, History). In all Communist countries until the 1980's, trade unions were used by the government to set production targets and to control workers. Free trade unions, and collective bargaining to improve pay and conditions, are not tolerated by totalitarian governments.

Collective bargaining. Unions seek for their members improvements in pay rates, hours of work, holiday allowances, and other conditions of work. They may *negotiate* (bargain) for a whole industry with employers' representatives from a number of companies. Agreements reached in this way are called *national agreements.* Such national agreements set out minimum terms, that may later be improved in private companies after local negotiations. In some industries, there may be only one union. In other industries, several unions may have members in the same factory.

Disputes between an employer and a union or unions are usually settled by procedures agreed between the two sides. If they cannot agree, a company or union may go to *arbitration.* A third party, such as the Advisory, Conciliation and Arbitration Service in the United Kingdom, is called in to help reach a settlement. If the two sides agree, the third party may appoint an independent adjudicator to make a final decision.

Strikes. A *strike* is the most drastic action a union can take against an employer. Striking union members *withdraw their labour* (refuse to go to work). See **Strike.** A company may take similar drastic action by shutting its gates against its workers. This is called a *lock-out.*

The union representatives in a particular office or factory are called *shop stewards.* They recruit new members and inform all members about union activities, and about the company's activities and plans. They also take members' suggestions and grievances to the company's management. Shop stewards report to the union's local branch. Since they too are company employees, shop stewards perform most of their union tasks outside working hours.

Closed shops. In some companies, all would-be employees must join the appropriate trade union before they can be hired. This is known as a *preentry closed shop.* Elsewhere, an employee may have to join a union *postentry,* that is within a certain time after accepting the job. A *closed-shop agreement* ensures that all those who benefit from union-negotiated agreements contribute to union funds.

The closed-shop principle is controversial. In the United Kingdom, changes to the law in the 1980's made it easier for employees to refuse to join a union. It became illegal for a company to dismiss any employee who chose to leave a union. In the UK, an 80-per-cent vote by union members is required to form a closed shop.

Organization and kinds of unions

Finance and structure. The work of a trade union is paid for by members' subscriptions. The money from members pays for the union's full-time staff, for conferences of members, and for services such as strike pay and educational courses.

Members run their own local trade union affairs through local branches. There are regional or district offices, and a national headquarters. Union affairs are run by a general secretary. He or she is elected, and is assisted by national officers, and by departments handling finance, membership, research, training, and other matters.

The *national executive* is a committee elected by members to govern the union and make sure that its policies are carried out. Union members can influence policy by submitting resolutions to the national executive, or to national conferences where union policy is discussed and decided by vote.

Craft unions. The first successful trade unions were set up by members of a single craft, such as printers or engineers. Local craft unions were formed in the UK in the 1700's. These craftworkers restricted the supply of their valuable skills by limiting the number of apprentices who could be trained. They did this to strengthen their bargaining powers.

Craft unions were weakened during the Industrial Revolution (see **Industrial Revolution**). New methods of work in factories ended many old crafts and brought in unskilled and semiskilled tasks. Most craft unions had to widen their membership to include noncraftworkers.

General unions. Many British trade unionists belong to general unions. These recruit members working in a wide range of industries and in many different occupations. The Transport and General Workers' Union, a general union, is the largest union in the UK. General unions were first formed in the late 1800's and early 1900's. The unions represented workers who did not have a special craft or skill.

Industrial unions aim to recruit all the workers in a particular industry, no matter what job they do. The advantages of an industrial union are that it does away with disputes between different unions in the same company and simplifies negotiations with management. Germany and Scandinavia have many industrial unions.

White-collar unions. New technology and other changes in industry have reduced the proportion of manual workers. There has been an increase in the proportion of *white-collar workers* (people who do clerical and other nonmanual work). Such workers include local government workers and teachers, who have well-organized trade unions. Organizations in other professions may not call themselves trade unions, but still operate in a similar way on behalf of their members.

Unions worldwide

Union organizations, practice, and strength vary from country to country. This section of the article describes trade unions in selected countries.

Australia. In the late 1980's, there were 3,213,000 trade union members in Australia, amounting to 40 per cent of the workforce. The largest of the 308 unions were the Australian Teachers' Federation (177,000 members), the Amalgamated Metal Workers' Union (155,730), the Federated Miscellaneous Workers' Union (127,000), and the Australian Workers' Union (122,000).

The central body is the Australian Council of Trade Unions, founded in 1927. It has 158 affiliated unions. Many unions also belong to the Australian Labor Party. Such links operate at state and territory level, not on a national basis. About 40 per cent of Australian union members are white-collar workers. Women make up about 32 per cent of the total.

Unions in Australia date from the 1800's. They were legalized in 1855, and there were at least 200 by 1890. The Conciliation and Arbitration Act was introduced in 1904 to settle wage disputes, and to fix wage rates and hours of work. In the 1940's and 1950's, the strength of Communist influence in unions caused internal conflict and national controversy. Membership rose, however, and by 1954 a record 61 per cent of all workers belonged to a union.

India. Social problems such as illiteracy and religious divisions have hampered the growth of trade unions in India. So have the facts that much work is seasonal, that unemployment is high, and that a large pool of casual labour is always available.

The employment of children under 15 years of age was outlawed in 1986, but remains widespread. Poverty contributes to the persistence of child labour in restaurants, factories, agriculture, and domestic service. Estimates suggest that there may be as many as 17 million child workers.

In the late 1980's, there were only about 10 million union members, out of a total workforce of 222 million. Two-thirds of all working people in India are employed in agriculture, but few of these belong to trade unions. Exceptions include those who work on tea and other plantations.

The Indian National Trade Union Congress was formed in 1947. In the late 1980's, it had 4.7 million affiliated members in 4,475 unions. It has strong links with the Congress Party. The All-India Trade Union Congress dates from 1920 and is allied to the Communist Party. It consists of 3,622 unions representing 3.4 million members. *Hind Mazdoor Sabha* (the India Labour Association) represents 2.5 million members in 1,400 unions. It was established in 1948. The Centre of Indian Trade

Unions has 3,000 affiliated unions with 1.8 million members. It was formed in 1970 and has Marxist political links.

The three largest unions are the Confederation of Central Government Employees and Workers (1.2 million members), the All India Railwaymen's Federation (833,000), and the National Federation of Indian Railwaymen (802,000).

Indonesia. The All-Indonesian Union of Workers (S.P.S.I.) is an association of ten national industrial unions and has a total of about 3 million members. It is largely organized by the national government. The Department of Manpower has successfully encouraged collective bargaining and the negotiation of agreements in industry, especially in those enterprises that employ skilled workers.

The first Indonesian trade unions were formed in the 1910's, mainly by employees of the government and in industrial activities owned and controlled by the government, such as railways.

Ireland. In Ireland, trade unions developed first in the 1800's when the country was under British rule. British practice influenced the organization of Irish unions.

In 1990, 78 unions, with a membership of 669,000, belonged to the Irish Congress of Trade Unions. Of these, 453,000 members were in the Republic and 226,000 were in Northern Ireland (part of the United Kingdom). Most unions in Northern Ireland are also affiliated to the British Trades Union Congress.

The largest unions are the Services Industrial, Professional and Technical Union (215,000 members), the Irish Transport and General Workers' union (150,000 members), based in Dublin, and the Amalgamated Transport and General Workers' Union (70,000), based in Belfast.

Malaysia. Under British colonial rule, ethnic Chinese employees in Malaya formed themselves into labour groups. After World War II (1939-1945), the Malayan Communist Party established the General Labour Union. The British sought to counter its influence by encouraging workers to form "free", or nonaligned, trade unions. In 1949, these unions set up the Malaysian Trades Union Congress (MTUC), which remains the sole trade union centre. From 1948 to 1960, under emergency legislation introduced to counter Communist subversion and terrorism, trade union activity was banned.

In modern Malaysia, major strikes are rare. Most labour disputes are settled by conciliation, sometimes with the help of the Ministry of Human Resources or in the Industrial Court. Workers in *free-trade zones* (business areas designed to encourage foreign investment) are not allowed to form in-house or company-based unions. Public servants are well-organized, but their collective bargaining rights are limited. Unions based in the Malay Peninsula may not recruit members in the eastern states of Sabah and Sarawak, and vice-versa.

Strikes are legal if they are carried out according to procedures laid down by law. But the government can force parties in a dispute to settle the matter by arbitration.

About 10 per cent of the workforce of Malaysia belongs to a trade union. In the late 1980's, there were 392 trade unions with 617,000 members. A total of 146 unions, representing about 500,000 members, belonged to the Malaysian Trades Union Congress.

A picket line patrols the entrance of a factory, office, or shop where workers are on strike. A strike or the threat of a strike is a bargaining weapon of organized labour.

The largest single unions were the National Union of Plantation Workers (82,000), and the National Union of Bank Employees (20,000). The federation of public sector unions is called the Congress of Unions of Employees in the Public Administrative and Civil Services (CUEPACS), and has 115,000 members.

New Zealand. Unions were legalized in New Zealand in 1878. In 1894, the Industrial Conciliation and Arbitration Act was passed, and served as a basis of industrial relations for almost 80 years.

Compulsory union membership has been a major political issue in New Zealand. In 1985, under changes introduced by the Labour government, 193 of the country's 230 unions voted in favour of compulsory union membership. In 1990, however, a new government formed by the National Party came to power, and committed itself to deregulate the labour market. By 1990, the number of unions had declined to 167, largely because of government-backed amalgamations.

In the late 1980's, the largest union in New Zealand was the Service Workers' Federation (72,000 members), followed by the Public Service Association (66,000). In 1987, the Federation of Labour, founded in 1937, merged with the public sector group, the Combined State Unions, to form the New Zealand Council of Trade Unions. Its affiliated members totalled 530,000.

Philippines. Trade unions were legalized in the Philippines in 1908. Union legislation was revised extensively in 1974 by President Marcos. He sought to unify the union movement, but also restricted the right to strike. In the 1980's, the government had the power, in the national interest, to ban strikes and impose compulsory arbitration. Strikers and those who organized pickets could be jailed if their activities were primarily protests against government policies. A two-thirds majority was required in any vote to approve strike action.

After President Aquino came to power in 1986, the one-union-per-industry law was abolished, and employees were allowed to choose their own type of union. New rules made it easier for unions to be formed, and strike action could be taken on a simple majority vote. National unions remain a powerful political force in the Philippines, and political demonstrations against government policies are frequent.

In 1988, a total of 3,127 unions had 4.93 million members. The Trade Union Congress of the Philippines (TUCP), formed in 1975, is the largest union centre with 3.8 million members. The largest group is the National Congress of Farmers' Organizations, which is allied to the TUCP, and which has 2.7 million agricultural workers.

The Federation of Free Workers was founded in 1950, and has 400,000 affiliates in 390 unions. *Kilusang Mayo Uno* (the *May the First Movement*) was formed in 1980, and represents 750,000 unionists.

South Africa. The history of South African trade unions dates from 1881, when the Amalgamated Carpenters' and Joiners' Union was founded. The growth of unions was hastened by the discovery of gold and diamonds in the late 1800's. The earliest unions were for whites only. The first black trade union, the African Commercial Workers' Union, was not established until 1919.

Blacks had to rely on bargaining at shop-floor level, because they were excluded from the industrial conciliation scheme introduced in 1924. From 1948, under the governing National Party's policy of *apartheid* (separate development), black unions faced many handicaps. They did not win legal recognition, including the right to strike, until 1979.

Black leaders viewed industrial action as a means of achieving political change and greater power, and union activity was used for this purpose. Under the national state of emergency which lasted from 1986 to 1990, hundreds of unionists were detained, strikers were killed in clashes with police, union offices were raided, and union officials were put on trial.

Despite this, trade union membership in South Africa increased strongly during the 1980's. In 1980, there were 188 registered unions with 808,000 members. By 1989, there were 212 unions with 2,130,117 members. In addition, there were about 85 unregistered trade unions with a membership of 550,000. Multiracial unions increased from 42 in 1980 to 109 in 1989; their membership during the same period rose from 286,934 to 942,332. In the late 1980's, union membership amounted to about 25 per cent of the workforce.

The Congress of South African Trade Unions (COSATU), formed in 1985, has 1,155,967 members. It includes South Africa's largest union, the National Union of Mineworkers (247,000 members). COSATU is closely allied to the South African National Congress. It has a history of political activity on behalf of blacks, and in opposition to government policies, especially apartheid.

The National Council of Trade Unions was formed in 1986, by the merger of two existing union groups. It has about 258,000 members.

The South African Confederation of Labour dates from 1956, and has a membership of 86,000. It represents white interests, and formerly supported racial segregation in union organization. With the introduction of political reforms in South Africa in the early 1990's, its influence lessened.

United Kingdom. The Trades Union Congress (TUC) represents the trade union movement in the UK. Founded in 1868, the TUC is the oldest trade union centre in the world. At the end of the 1980's, 76 unions with 8,416,832 members belonged to the TUC. The TUC voices union views on economic, political, industrial, and social matters, and also represents trade unions in talks with the government. It cannot interfere in a union's affairs, but gives advice if asked to do so. An annual *congress* (conference) is attended by delegates from member unions, who decide TUC policy.

An elected general secretary is the TUC's chief executive. A general council of leading union officials meets regularly to see that conference decisions are carried out. Trades councils act as local agents. The TUC provides extensive training programmes for union officials.

The Scottish Trades Union Congress is a separate body. It has functions similar to those of the TUC, but concentrates on issues of particular relevance to Scotland. It has a general secretary and a small administrative staff.

Trade union membership declined during the 1980's. In 1980, there were 438 unions with 12,947,000 members. In 1988, there were 314 unions with a membership of 10,238,000. About 55 per cent of the workforce belonged to unions in 1979, but the figure dropped to 43 per cent by 1987.

Unemployment rose in the early 1980's, and the government introduced new restrictions on union activity. As a result, UK trade unions had lost some power by the beginning of the 1990's. Many unions accepted low pay rises in order to protect jobs. More workers took early retirement, worked part-time or became self-employed, or were not union members.

United States. About 17 million nonagricultural workers were union members in the late 1980's, representing about 17 per cent of the workforce. This percentage is a decline from 36 per cent in 1945.

The United States has about 60,000 local unions and more than a hundred national and international trade unions. Several large unions are independent of the central body, the American Federation of Labor and Congress of Industrial Organizations (AFL-CIO).

At least six unions have a membership of well over a million. The largest include the Teamsters Union (2 million members), the National Education Association of the United States (an independent teachers' association with 1,600,000 members) and the United Food and Commercial Workers International Union (1,300,000).

Nationwide unions first developed during the mid-1800's, but the labour movement grew unsteadily, hampered by episodes of violence, opposing legislation, and conflicts with constitutional rights. The Great Depression, which started in 1923, helped to improve conditions for the success of organized labour.

More recently, the decline in membership has been blamed on increasing automation, low-cost foreign competition, and on inefficiency and corruption in the unions.

International union organizations. There are two main international trade union organizations. The World

Federation of Trade Unions (WFTU), formed in 1945, is dominated by unions of workers in Communist countries. It had a membership of 214 million in 1989. By the early 1990's, its importance had declined, following the collapse of Communist governments in several countries of Eastern Europe. The International Confederation of Free Trade Unions was founded by union groups that broke away from the WFTU in 1949. By 1990, it had 95 million members in 98 countries.

The International Labour Organization is an agency of the United Nations. It was created in 1919 and seeks to improve workers' conditions and terms of employment through international agreement. See **International Labour Organization.**

Related articles in *World Book* include:

Apprentice
Automation
Bevin, Ernest
Blacklist
Child labour
Closed shop
Guilds
Industrial relations
Industrial Revolution (The working class)
Industry (Labour)
Labour force
Labour Party
Minimum wage
Open shop
Pension
Piecework
Profit sharing
Sweatshop
Syndicalism
Wages and hours
Walesa, Lech

Outline

- **I. What unions do**
  - A. Collective bargaining
  - B. Disputes
  - C. Strikes
  - D. Closed shops
- **II. Organization and kinds of unions**
  - A. Finance and structure
  - B. Craft unions
  - C. General unions
  - D. Industrial unions
  - E. White-collar unions
- **III. Unions worldwide**
  - A. Australia
  - B. India
  - C. Indonesia
  - D. Ireland
  - E. Malaysia
  - F. New Zealand
  - G. Philippines
  - H. South Africa
  - I. United Kingdom
  - J. United States
  - K. International union organizations

Trade wind is a strong wind that blows toward the equator from the northeast or southeast. In the days of sailing ships, sailors depended greatly on trade winds. The paths of these winds were so regular, especially over the oceans, that early navigators named them *trade winds,* which meant *course,* or *track,* winds.

The trade winds are part of a great system of winds that blow over the earth. The winds blow toward the equator from about the 30th parallels of north and south latitude.

Differences between the temperature in low latitudes and the temperature in the polar regions cause trade winds. The heating of the air in low latitudes makes it expand and become light. Then it rises. This creates an area of low pressure near the surface. Cooler and heavier air from the polar regions then tends to flow in to fill the area of low pressure. These polar winds do not blow due north or due south, because of the eastward whirling of the earth. Instead, these winds blow from the northeast and from the southeast.

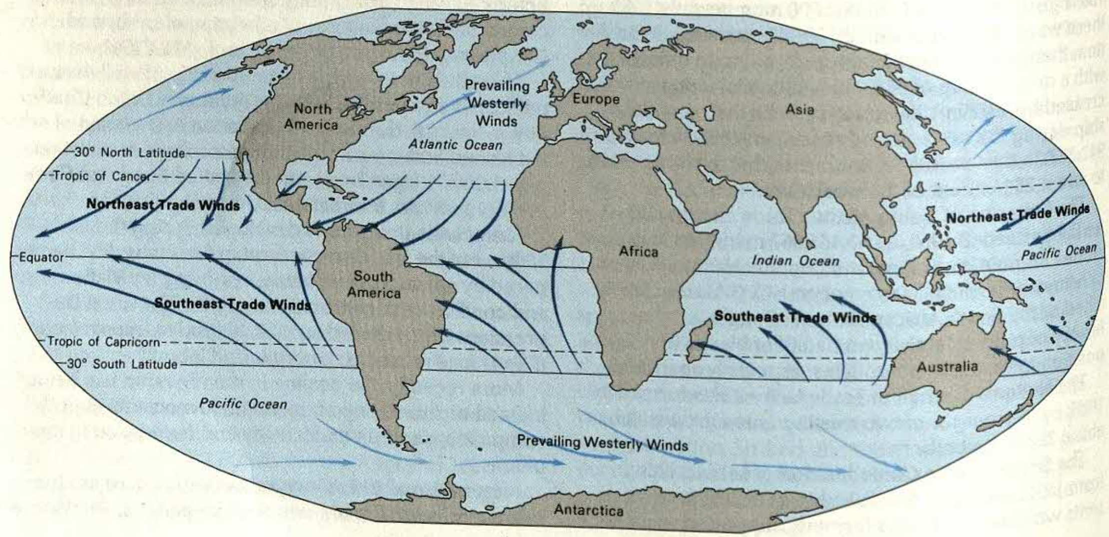
The belt of rising air between the trade winds is a region of mild winds and calms. This region is often called the *doldrums* because it is so calm. Sailing ships of early days were often stranded for many weeks in the doldrums.

Trade winds have a great deal to do with rainfall on land. When trade winds blow against mountain ranges, they are forced upward. As the warm air rises, it cools. Its moisture condenses and falls as rain on the mountain slopes.

See also **Calms, Regions of; Doldrums.**

Trademark is a word or words, a name, a design, a picture, a sound, or any other symbol that distinguishes the products of one particular firm or company from those of another. A trademark also may consist of any

Trade winds are strong winds that occur chiefly in the earth's Tropical Zone. They blow steadily toward the equator from both the northeast and the southeast. Trade winds blow mostly over the oceans because the weather there is more uniform than over the continents.



combination of these identifications. Most trademarks appear on the product, on its container, or in advertisements for the product. A *service mark* identifies the source of a service rather than a product. For example, an electric company may use a lightbulb as a symbol of the service it offers.

Other types of marks are those used by professional or trade associations to show a firm is a recognized member of the trade or association, and certification marks used by associations to show that a product has been tested for quality or safety.

Trademarks, also called *brand names,* provide an easy way to determine who makes a certain product. They help consumers identify brands they liked in the past so they can purchase them again. A trademark represents the manufacturer's reputation, called *good will,* and for this reason has a real economic value.

Most countries have laws that protect the rights of trademark owners. A firm must establish its rights in each country in which it seeks protection. Many governments allow a company to register a trademark before using it. Some require registration before any trademark rights can be enforced.

A registered trademark becomes the property of the person in whose name it is registered. Once a trademark is registered, it is an offence for anyone except the owner to use it, or to use a similar one likely to deceive or confuse the public. Because a trade mark is property, it can be leased to other manufacturers. This is often done by one company to another manufacturing the same or similar goods in a foreign country.

A trade mark may be lost to a company if the name is so well known that it becomes a generic term for the product. Each country has its own rules as to how trade marks are lost. In some, the opinion of the general public is used; in others, members of the relevant trade are consulted. Trademarks that have become generic terms in some countries include Aspirin, Biro, and Hoover.

An international agreement, known as the Paris Convention, gives protection to trade mark holders in member countries. They receive the same protection for their trade marks in other member countries as that country grants to its own trade mark holders.

See also **Counterfeiting; Patent; Property.**

Tradescantia is the name of about 65 *species* (kinds) of plants with attractive foliage and three-petalled flowers. Tradescantias are native to Central and South America. In temperate regions, species such as the *wandering jew* are popular house plants. The name wandering jew usually refers to a species with green and white striped leaves and white flowers, which is often planted in hanging baskets. A similar species has red flowers and leaves with silvery bands. These plants are best repotted each spring, as they rarely look good after two growing seasons.

Spiderwort is a species of tradescantia native to eastern North America. It has green and white striped leaves and blue, purple, or white flowers, depending on the cultivated variety. Spiderwort is often grown as a garden plant.

Scientific classification. Tradescantias belong to the family Commelinaceae. The wandering jew is *Tradescantia albiflora* and the red-flowered species is *T. zebrina.* Spiderwort is *T. virginiana.*

Trading post is a type of market place where people bring products to sell or to exchange for other goods. In the United States, many posts serve Navajo Indians who live on a large reservation in Arizona, New Mexico, and Utah. At these posts, the Indians sell goods and buy food, clothing, and farm equipment.

In ancient times, trading posts operated in the Near East. Later, Europeans set up trading posts as they explored various parts of the world. At first, before the development of money, traders usually *bartered* with one another—that is, they exchanged items for other items.

The first trading posts in North America were established during the late 1400's in what is now Newfoundland, Canada. By the mid-1800's, trading posts had been set up throughout North America. Indians traded furs and hides to whites for such items as cloth, glass beads, guns, gunpowder, liquor, and metal goods.

Many settlements that grew up around trading posts developed into large U.S. and Canadian cities. These communities included Chicago; Detroit; Kansas City, Missouri; Montreal; and Quebec.

See also **Hudson's Bay Company.**

Trading stamps are *premiums* or *bonuses* that a retailer gives with a cash purchase of goods. People collect the stamps to exchange them for some item of value or to receive a discount on the retailer's merchandise. Trading-stamp companies sell the stamps to retailers. They also *redeem* (exchange) them for various products, such as appliances, housewares, or sports equipment. Cooperative shops may give stamps with each purchase. These may be exchanged for goods in a cooperative shop. The American businessman Thomas Sperry set up the first independent trading-stamp company in 1896. Though use of trading stamps has declined, they are still given by some companies to stimulate sales.

Trading standards ensure fair and honest trading. In Britain, county councils administer trading standards departments, which apply central government regulations on consumer legislation. Trading standards departments have responsibility in many areas, including quality control and weights and measures. They also enforce the Trade Descriptions Act.

The Institute of Trading Standards Administration promotes the work of local authority trading standards

The tradescantia, known as wandering jew, has striped leaves. It is an ideal plant for hanging baskets.

officers. The Local Authorities Co-ordinating Body on Trading Standards promotes three-way cooperation among trading standards departments, the central government, and British industry. It also helps enforce European Community regulations. In most industrial countries, similar systems exist.

Trafalgar, Battle of, fought on Oct. 21, 1805, is one of the major naval battles in history. Admiral Horatio Nelson's British fleet defeated a combined French and Spanish fleet. The victory gave Great Britain undisputed control of the sea. Nelson was wounded and died during the battle.

The battle occurred during Great Britain's war against Napoleon Bonaparte (see **Napoleon I**). Napoleon hoped to draw the British fleet away to the West Indies so his armies could invade England. But Napoleon's admiral, Villeneuve, failed in this, and decided to attack the British fleet with a French and Spanish fleet. His fleet outnumbered Nelson's, 33 ships to 27. But Nelson surprised the enemy by having his ships cut through the French battle line. The British fleet did not lose a ship in the battle, but it destroyed or captured over half the French and Spanish ships. Trafalgar Square in London was named in memory of Nelson's victory.

See also **London** (map); **Nelson, Horatio.**

Traffic is the movement of people and goods from one place to another. This article deals with traffic on streets and highways. For a discussion of other kinds of traffic, see **Transportation** with its list of *Related articles.*

The United States has more roads than any other country, about 6,400,000 kilometres. The average American passenger car covers about 14,800 kilometres a year. India has about 1,550,000 kilometres of roads, Australia about 853,000 kilometres, and South Africa about 183,000 kilometres.

Traffic drives on the right in most countries. In some countries, including Australia, India, Japan, the Philippines, and the United Kingdom, traffic keeps to the left.

Traffic problems

The millions of motor vehicles on the roads of many countries cause many traffic problems. In the morning and evening rush hours, city streets are often jammed with cars. Main roads linking cities are often too crowded for comfort or safety. Motorways have been built to replace smaller streets, roads, and highways. They are constantly being maintained and improved to relieve crowded conditions. The main streets of many small towns are overburdened with through traffic, making it difficult for local people to get about. Bypasses around these towns ease the pressure and help local business. It is hard to find a parking place in the centres of many cities and towns. Parking at the roadside is being prohibited in more and more places in order to make additional street space available for traffic. Off-street parking areas are often needed to deal with shopping and business traffic.

Improved public transport systems help relieve congestion when the service is convenient, comfortable, and inexpensive. Better provision for truck loading and unloading at shops, office buildings, and factories eases the problem of delivery vehicles blocking streets. It also reduces cost of delivery and distribution of goods. More efficient use of existing streets is obtained in several ways. These include: (1) creating one-way streets; (2) changing traffic lanes to one-way operation during hours of heavy traffic; (3) prohibiting parking at the kerb; (4) installing modern coordinated traffic-signal systems, and pedestrian controls; and (5) developing through-street systems to move traffic faster.

Traffic control

Throughout the world, many thousands of people are killed or seriously injured each year in traffic accidents. Drivers and pedestrians can reduce the number of traffic accidents, injuries, and deaths by watching and obeying traffic control signs, signals, and pavement markings. Special control devices, such as electric signs that tell when to cross busy roads, are often used to aid pedestrians. These signs operate in conjunction with vehicle traffic signals.

Signals, signs, and markings. There is no clear record of who invented or first used traffic control devices. It is generally agreed, however, that automatic traffic signals first appeared in Detroit, in the United States, in the early 1920's. Before then, police controlled traffic, using hand signals. Police and other traffic officials are still used in traffic control. Another improvement was the use of a white centre line for separating driving lanes on roads. Traffic signs date from the early Roman roads.

Traffic controls are increasingly necessary for regulating, warning, and guiding motor vehicle and pedestrian traffic. The law requires signs to indicate how certain traffic regulations apply. Adequate use of warning signs, and well-designed and well-located road signs have great value, too, in helping the flow of traffic. Pavement and kerb markings and traffic islands, when properly designed and located, also help guide traffic.

Modern traffic lights are made so that they can be set to change when traffic demands it. In most places, the changes are automatic every so many seconds or minutes. Where there are different amounts of traffic on intersecting roads, the light can be set so that it will remain green longer for the road with the most traffic. Some traffic lights also are arranged so that the traffic itself will cause them to change. This is done by placing switches or magnets on the roadway. These are called *detectors.* When cars pass over the detectors, the light changes to let the cars go through the intersection. To control pedestrian traffic across a busy road, special signals work from a switch operated by the pedestrian.

Many warning and guide signs are covered with luminous paint, or glass or metal beads or buttons, which reflect beams from headlights. This makes the signs easier to see at night. Traffic lanes, pedestrian crossings, turn markings, and warning signs are frequently painted or otherwise marked. Sometimes, various types of reflector buttons or white material are embedded in the surface of the road.

Control devices must be located in the right places or they can cause delay and congestion, and lead drivers and pedestrians to disregard them. Good traffic control devices must be based on sound engineering principles. Studies of types and flow of traffic, accidents, speeds, delays, and physical conditions show the exact nature of a traffic difficulty and indicate the particular devices or methods of control that are needed.

Traffic regulations are the rules of the road governing the actions of pedestrians and drivers on public roads and streets. Regulations should be uniform, so that drivers everywhere will know exactly what actions to take under like conditions.

Parking meters were first used in Oklahoma City in the United States in 1935. Parking meters are used to restrict the length of time vehicles are allowed to park, or to collect parking fees.

Traffic police enforce traffic-control measures and regulations, and control traffic emergencies. Development of street and highway facilities and traffic-control plans are the responsibilities of highway or traffic engineers.

Related articles in ***World Book*** include:

Bicycle
Bus (Importance of buses)
Car
Police
Radar (In controlling traffic speed and flow)
Road
Safety

Trafford (pop. 205,700) is a local government district in the metropolitan county of Greater Manchester, England. It is bounded in the west by the Manchester Ship Canal. Altrincham, Carrington, and Trafford Park, the district's main industrial areas, produce a variety of manufactured goods. In the south, Hale is mainly residential, and there are some rural areas. See also **Manchester, Greater.**

Tragacanth is a true gum obtained from various shrubs (Astragalus) of the pulse family. These shrubs grow mainly in Asia Minor, Iran, and Syria. Tragacanth is dull white or yellowish in colour, and clear and hornlike in texture. It is usually sold in thin flakes or ribbons which swell into a jellylike mass when soaked in water. The use of tragacanth in pharmacy dates back to Biblical times. Today, it is used in preparing pills, emulsions, and creams. It is also occasionally used in making printing gums for textiles.

Tragedy is a form of drama that deals with serious human actions and issues. Tragedy explores questions about morality, the meaning of human existence, relationships between people, and relationships between people and their gods. By the end of most tragedies, the main character has died or lost his or her loved ones.

Playwrights have written tragedies throughout the history of drama. The most famous were written during three periods—the 400's B.C. in Greece, the late 1500's and early 1600's in England, and the 1600's in France.

The greatest writers of Greek tragedy were Aeschylus, Euripides, and Sophocles. They took most of their plots from Greek mythology. William Shakespeare was the principal tragic dramatist of the English period. His tragedies are noted for their suspenseful plots, insights into human nature, and powerful poetic dialogue. Other leading English playwrights of the period include Christopher Marlowe and John Webster. Jean Racine dominated tragic drama during the French period. His tragic heroes and heroines are victims of violent passions they cannot control. Pierre Corneille was another important French tragic playwright of the 1600's.

Until the 1700's, almost all tragedies dealt with royalty, famous historical figures, or other notable people. Playwrights did not consider the lives of common men and women important enough to provide material for tragedies. After 1700, a number of dramatists wrote *domestic tragedies,* plays with middle-class people as heroes and heroines. Perhaps the most important of these playwrights was Gotthold Ephraim Lessing of Germany.

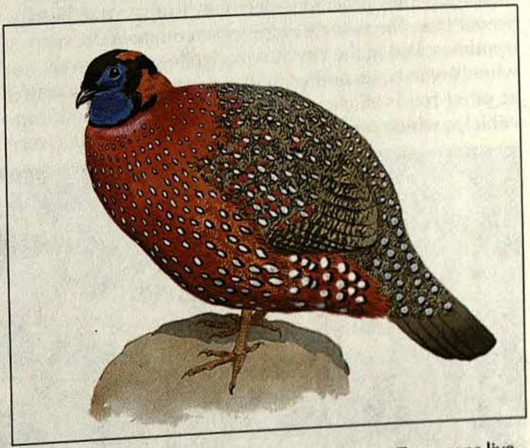
Notable tragedies of the late 1700's and early 1800's were written by Friedrich Schiller of Germany and Victor Hugo of France. Most of their works dealt with famous or powerful characters.

Critics disagree about whether any true tragedies have been written since the late 1800's. Some argue that serious plays of this period lack the moral, philosophical, or religious significance required for genuine tragedy. Other critics believe several playwrights have created works that can be considered tragedies. These playwrights include Georg Büchner of Germany, Henrik Ibsen of Norway, and Arthur Miller and Eugene O'Neill of the United States.

Each playwright discussed in this article has a separate biography in *World Book.* See also **Drama; Aristotle** (Literary criticism).

Tragopan is the name of five species of handsome quaillike birds of the pheasant family. Tragopans live in forests high on mountain slopes of southern and central Asia. Males have a bright-coloured *lappet* (loose-hanging skin) on the throat, and a pair of blue, fleshy, erectile horns on each side of the head. Both lappet and horns become enlarged and brilliant during the mating season.

Tragopans eat insects, leaves, fruit, and seeds. They nest in trees. Most other pheasants nest on the ground. Their white eggs are slightly speckled with dull lilac. Tragopans are shy. Hunters usually snare them by driving them slowly toward nooses.



A tragopan has colourful, handsome markings. Tragopans live in mountain forests of southern and central Asia.

Scientific classification. The tragopan belongs to the family Phasianidae and makes up the genus *Tragopan.* The best known of the five species is *T. satyra,* the satyr tragopan of the Himalaya.

Trailing arbutus. See **Arbutus.**
Train. See **Electric railway; Locomotive; Railway.**
Training school. See **Reformatory.**
Trait. See **Heredity** (The physical basis of heredity).
Traitor. See **Treason.**

Trajan (A.D. 53?-117) was a Roman emperor and an important military leader. He expanded the empire by conquest and carried out extensive building programmes. Trajan conquered Dacia (now parts of Romania and Hungary) and made Nabataea part of the Roman Empire. Nabataea was a kingdom in what are now southern Jordan and northwestern Saudi Arabia. Trajan also won victories along the western frontier of Parthia, in present-day Iraq. He founded new cities, including Thamugadi (now Timgad, Algeria), and built bridges and harbours. These included bridges across the Danube River in Dacia and a new harbour at the port of Rome. Trajan also introduced a programme for the support of children in Italian cities.

Trajan was born Marcus Ulpius Traianus in Italica, Spain, of Roman parents. His father was a senator who became governor of Syria, an important province. Trajan became a senator and served in military posts in Spain, Syria, and Germany. In A.D. 97, Emperor Nerva adopted Trajan as his heir and successor. When Nerva died in A.D. 98, Trajan was declared emperor.

Trajan's Column is a monument built in the emperor's honour after he conquered Dacia. It was dedicated in A.D. 113. The well-preserved column, 30 metres high, stands in Trajan's Forum in Rome. A spiral staircase inside the column leads to the top. The column and its pedestal are covered with carvings portraying events of the Dacian wars. The ashes of Trajan are said to have been placed in the column, but no trace of them has ever been found.

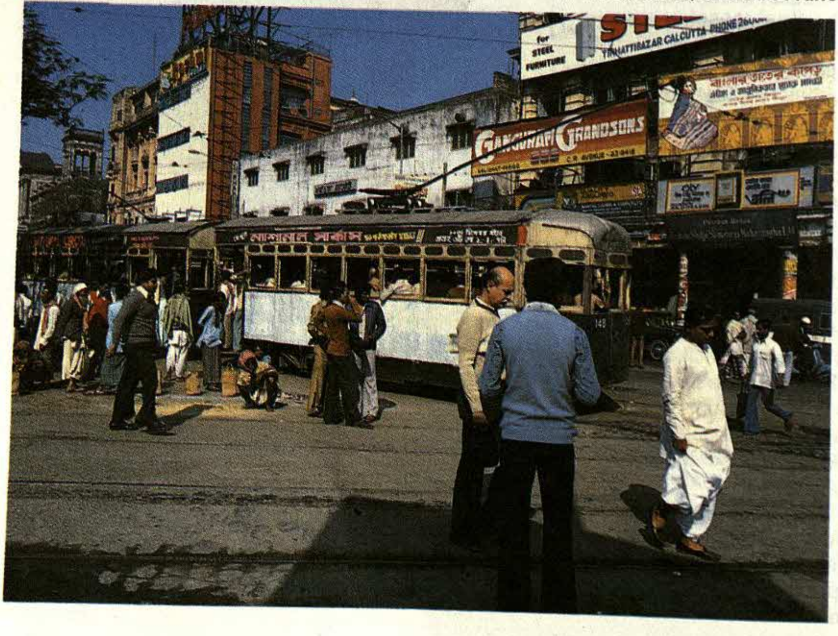
See also **Rome** (picture: Trajan's Column); **Sculpture** (picture: Trajan's Column [detail]); **Library** (Libraries of papyrus).

Tram and trolleybus are types of city passenger vehicle, generally driven by electricity from an overhead power line. The wheels of trams run on metal rails, or tramlines, laid in the city streets. Trolleybuses have wheels with tyres, and can be steered in the same way as other road vehicles. The first trams were horsedrawn vehicles which ran on iron rails in coal mines. Rails were later laid in streets and the cars carried people. These trams, called *horse-cars,* first ran in New York City in 1852. By the early 1860's, trams were running in cities in the United Kingdom and other industrial parts of Europe.

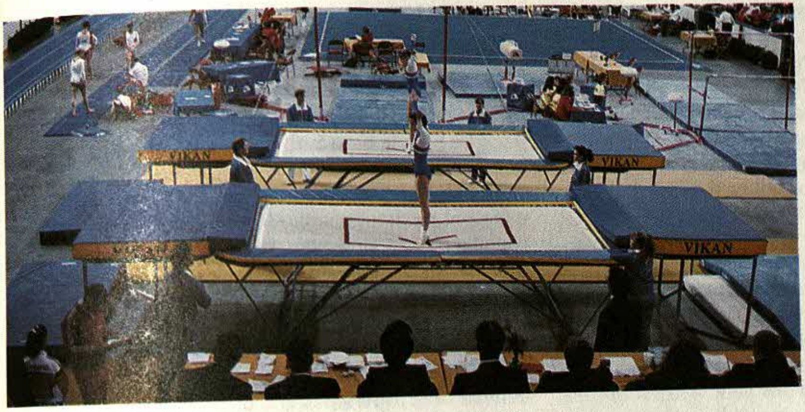
The next method tried for powering trams was an endless loop of cable, running between the rails, to which the tram clamped itself. This system of propulsion was used in San Francisco in 1871, where the cable was moved along by the power of a steam engine in an engine house. *Cable cars* are still to be found there and some other parts of the world, though they no longer use steam engines. Other trams tried in the 1870's and 1880's had built-in steam engines or compressed-air engines. These were not a success, because they were unreliable, dirty, or unsafe.

The first electric trams, appearing about 1883, were not very successful. They were powered by heavy electric batteries which greatly increased the weight of the trams and needed recharging every few hours.

In 1888, Frank J. Sprague demonstrated his *streetcar* in Richmond, Virginia, U.S.A. This was the first tram to take electricity from an overhead power line, by means of a *trolley* consisting of a pole with a small wheel that rolled along the line. This method has been generally used for trams and trolleybuses ever since. Electric current flows from the overhead line through the trolley to power the motor. Trams and trolleybuses powered in this way are safe and efficient, and can travel anywhere there is a power cable. In the early 1900's, they spread to cities all over the world. The use of trams declined in the U.S.A. and in many European cities after World War II (1939-1945). Since the 1970's, however, there has been renewed interest in trams, because they use less energy per person and create less pollution than cars or buses do. In Manchester, England, for example, trams have been reintroduced to help combat pollution and traffic congestion. Today, trams operate in many major cities worldwide, including Amsterdam; Budapest; Calcutta; Melbourne; and San Francisco.



A tram moves on rails laid in city streets. Most trams are electrically powered. They provide transportation for people in a number of cities in various countries. The vehicle shown on the left is part of the tram system in Calcutta.



The trampoline is a device used to perform aerial tumbling exercises. Trampolines used in competition, *left,* have large thick pads called *safety platforms* attached to the short sides. Spotters stand along the sides without a safety platform. Judges at the table in the foreground score the athlete's performance.

Trampoline is a device that a person bounces or jumps on to perform aerial tumbling exercises. Trampolines may be used for recreation or for competition.

Trampolines may be circular or rectangular. They consist of a bed of solid or woven material that is suspended from a steel frame by rubber cords or padded steel springs. Trampolines are supported by legs nearly 1.2 metres high. Trampolines used in national and international competition are rectangular and have frames about 5.1 metres long and 2.9 metres wide. Trampolines used in competition must also have large thick pads, called *safety platforms,* attached to the two short sides. These are 3 metres long and 2 metres wide.

A number of safety rules should be followed to avoid injury while using a trampoline. At least one qualified supervisor should be present. Only one person should perform at a time. One or more *spotters* should stand along any side without a safety platform to protect the athlete if he or she bounces off the trampoline. Somersaults should be prohibited except in competitive programmes with qualified instructors.

During competitive training, *spotting belts* are often used when practising difficult skills, such as somersaults. The belt is attached to an overhead rig and fastened around the athlete's waist. A rope-and-pulley system attached to the rig enables the instructor to control the athlete's movements. For example, the instructor might suspend the athlete in mid-air to prevent an unsafe landing. Some trampolines are placed in a "pit" so that the frame and bed are at floor level. Trampolines should be inspected often for damage and kept locked away when not in use.

Trance is a term that is generally used to describe any kind of unnatural sleep or partly conscious state. The term may be used to describe the condition of hypnotized people, spiritualist mediums, and some people with mental disorders. In some cases, trances continue for long periods. Usually, however, they last for only brief periods of time. The word *trance* was first used to describe conditions in which the soul was believed to have withdrawn from the body for a period of time.

There are no physical signs that always indicate a trance. But in many cases, the pulse and breathing rate slow down. A person in a trance is less responsive to changes in surroundings, and may not know what is happening. The person may appear to be responding to forces not actually present.

The best-known type of trance is probably that of the spiritualist medium who appears to be asleep, but can still speak and write. Such a trance may be similar to a deep hypnosis, and it may involve hallucinations.

See also **Hypnotism.**

Tranquillizer is a drug that calms a person by acting on the nervous system. Tranquillizers belong to a group of drugs called *antianxiety and hypnotic drugs.* Such drugs were formerly referred to as *depressants.* They do not cause depression, but will reduce a person's nervous activity.

There are two types of tranquillizers—*antipsychotic drugs* and *antianxiety drugs.* Antipsychotic drugs are used to treat patients with *psychoses* (severe mental illnesses). Antianxiety drugs are used to treat various emotional problems, particularly anxiety.

Antipsychotic drugs include such drugs as chlorpromazine, fluphenazine, and trifluoperazine. Doctors prescribe these drugs to treat *schizophrenia,* a mental illness that is characterized by illogical, unpredictable thinking. The drugs reduce the confusion and excitement experienced by the patient.

Antianxiety drugs include alprazolam, diazepam, and lorazepam, which are commonly known by the trade names Xanax, Valium, and Ativan, respectively. They relax the muscles and reduce tension. Doctors use antianxiety drugs to calm children who must undergo surgery. In addition, antianxiety drugs are used to treat *delirium tremens,* a disorder that results from alcoholism.

Some tranquillizers have undesirable side effects. For example, meprobamate may cause muscle weakness and general fatigue. Some people become addicted to tranquillizers. In addition, tranquillizers may cause drowsiness, especially if a person drinks alcoholic beverages before or after taking the drugs. A person should not drive a motor vehicle for several hours after taking a tranquillizer.

See also **Depressant; Drug** (Depressants).

Transactional analysis is a method of psychotherapy. In this method, therapists treat emotional problems by helping people to analyse their relationships in social situations. Such situations are called *transactions.* Eric L. Berne, a Canadian-born psychiatrist, developed the method during the 1960's. Interest in transactional analysis was stimulated by two best-selling books—*Games People Play* (1964), written by Berne, and *I'm OK—You're*

OK (1969) by Thomas A. Harris, an American psychiatrist.

Berne regarded the human personality as consisting of three "selves"—the *Child,* the *Parent,* and the *Adult.* According to Berne, any of these "selves" may be in control of a person during a transaction. The Child is dependent, impulsive, fun loving, and creative. The Parent is stern and critical. The Adult is capable of logical thinking. Transactional analysis is based on the idea that people can learn to use the Adult to think and make decisions for themselves.

Berne thought that transactions can be understood by analysing *games* in communication. A game is a transaction in which people deceive themselves or others. For example, people who blame their problems on others may be playing a game that Berne called "See What You Made Me Do." Berne believed that people use *scripts*—that is, life plans that they learn in childhood and later feel forced to act out. The games are part of the script.

Trans-Alaska Pipeline System. See **Pipeline** (Major pipelines of the world).

Transatlantic cable. See **Cable.**

Trans-Australian railway. See **Railway** (Railways around the world).

Trans-Canada Highway stretches about 8,000 kilometres across Canada and links the 10 provinces. It runs from St. John's, Newfoundland, on the Atlantic coast to Victoria, British Columbia, on the Pacific coast. The toll-free, two-lane road was officially opened in 1962.

The all-weather road made many areas, especially in western Canada, easier to reach and opened them to new economic development. It also has attracted larger numbers of tourists to Canada's national parks. The route goes through Glacier, Mount Revelstoke, and Yoho national parks in British Columbia; Banff in Alberta; and Terra Nova in Newfoundland.

Motorists driving westward along the Trans-Canada Highway travel through the Atlantic Provinces; Montreal, Canada's largest city; Ottawa, the Canadian capital; the upper Great Lakes region; the western prairie wheat fields; and the Rocky Mountains to Vancouver Island.

Transcendental Meditation (TM) is a method of relaxing the body that became popular in many countries during the 1970's. It was developed in the 1950's by the Maharishi Mahesh Yogi, a Hindu monk from India. He used the word *transcendental* to describe the process of reaching a state of *pure consciousness,* where the mind is not aware of anything in particular. He declared that people who used this technique became happier and more relaxed and creative. Centres that teach TM operate in many countries. Followers of the Maharishi call TM the Science of Creative Intelligence.

People practise TM by sitting quietly in a comfortable position. They close their eyes and silently repeat their *mantra,* a pleasant-sounding word from the Hindu scriptures. Teachers of TM select a personal, secret mantra for each student. A person who practises TM meditates for 15 to 20 minutes in the morning and evening, before meals.

Scientific studies show that certain bodily changes occur during meditation. For example, the rate of breathing and the amount of oxygen taken in by the body decrease. The blood pressure and the rate of heartbeat also decrease while a person meditates.

In addition, scientists found that *alpha waves* (brain waves that become prominent when a person is relaxed) increase in intensity during meditation. Psychologists report that many people who practise TM feel less anxious and aggressive than before and can handle stress more easily. Some scientists believe TM causes these changes because people have faith in the method and expect it to help them.

The Maharishi claimed that people cannot meditate effectively without training from a TM teacher and the use of a mantra. However, many scientists declare that other forms of meditation and relaxation can produce the same results as TM.

Transcendentalism was a philosophy that became influential during the late 1700's and 1800's. It was based on the belief that knowledge is not limited to and solely derived from experience and observation. It thus opposed the philosophy of empiricism—that knowledge comes from experience. Transcendentalism also stated that the solution to human problems lies in the free development of individual emotions.

According to transcendentalism, reality exists only in the world of the spirit. What a person observes in the physical world are only appearances, or impermanent reflections of the world of the spirit. People learn about the physical world through their senses and understanding. But they learn about the world of the spirit through another power, called *reason.* The transcendentalists defined reason as the independent and intuitive capacity to know what is absolutely true.

Elements of transcendentalism can be found in the Neoplatonic philosophy of ancient Greece (see **Neoplatonism**). But the chief source of transcendentalist ideas was the *Critique of Pure Reason* (1781) by the German philosopher Immanuel Kant (see **Kant, Immanuel**).

Transcendentalism began among Unitarians in the New England states of the United States, where it became both a philosophy and a literary, religious, and social movement. It reached its peak during the 1840's. Ralph Waldo Emerson was the leading American transcendentalist. He taught that the physical world is secondary to the spiritual world. But, said Emerson, the physical world serves humanity by providing useful goods and by making human beings aware of beauty. Emerson believed that people should learn as much as possible through observation and science. But he insisted that they should adjust their lives primarily to the truths seen through reason.

Emerson and his followers believed that human beings find truth within themselves, and so they emphasized self-reliance and individuality. They believed that society is a necessary evil. They argued that to learn what is right, a person must ignore custom and social codes and rely on reason. The transcendentalists believed that the doctrines and organized churches of orthodox Christianity interfered with the personal relationship between a person and God. The transcendentalists said that individuals should reject the authority of Christianity and gain knowledge of God through reason.

The American transcendentalists never became numerous, but their writings greatly influenced American intellectual history and literature. Besides Emerson, the leading American transcendentalists included Bronson Alcott, Margaret Fuller, Theodore Parker, and Henry David Thoreau.

Transducer is a device that converts one form of energy into another. Many transducers convert electric waves into mechanical vibrations—or vice versa. Loudspeakers, microphones, and record player pickup cartridges are all transducers. *Sonar transducers* send and receive sound waves in water. *Ultrasonic transducers* generate and detect vibrations above the frequency range of human hearing. They are used to cut hard materials, to clean delicate instruments, to drill oil wells, and to measure the level of liquids in the fuel tanks of space vehicles.

Transducers work in various ways. Some phonograph cartridges use *piezoelectric* materials, which produce a voltage when squeezed. Loudspeakers use moving coils that vibrate when current moves through them. The vibrations result from an interaction between the coils and powerful permanent magnets. Some ultrasonic transducers use *magnetostrictive* materials, which contract in a magnetic field.

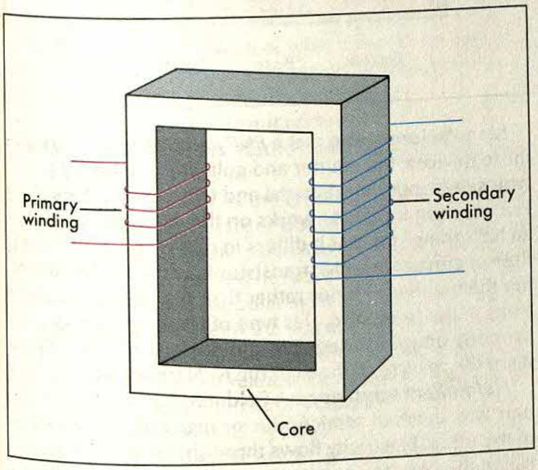
See also **Ultrasound.**

Transexualism. See **Transsexualism.**

Transfiguration was the change in physical appearance that came over Jesus Christ on one occasion during His ministry. It is described in the Gospels of Matthew, Mark, and Luke. According to these Gospels, Jesus took Peter, James, and John up on a mountain, and permitted them to see Him in splendour, with His face shining like the sun, and His garments bright with light. Then the Old Testament figures of Moses and Elijah came to talk with Christ. Raphael's altarpiece *The Transfiguration*, said by many to be one of the world's greatest paintings, now hangs in the Vatican (see **Raphael**).

Transformational grammar. See **Chomsky, N.**

Transformer is a device that increases or decreases the voltage of alternating current. Transformers provide a simple, inexpensive way to change such voltage. They enable electric power companies to transmit alternating current easily and efficiently. They also ensure the proper voltage for the circuits of home appliances, lights, industrial machinery, and other electric equipment.



A typical transformer consists of two coils of wire wound around the sides of a core of thin iron sheets. The ends of the primary winding are connected to the source of the voltage that is to be changed. The ends of the secondary winding are connected to the circuit to which the electricity is to be transferred.

Most transformers consist of two coils of insulated wire. One coil, known as the *primary winding*, is connected to the source of the voltage that is to be changed. This voltage is the *input voltage* of the transformer. The other coil, called the *secondary winding*, supplies the *output voltage* to the desired circuit. In most transformers, the primary and secondary windings are wound around a hollow core made of thin iron or steel sheets. Most cores have the shape of a ring or a square. The two coils are not connected to each other.

Transformers work by means of *electromagnetic induction* (see **Electromagnetism**). When the input voltage is applied to the primary winding, it generates alternating current in the coil. As the current flows, it sets up a changing magnetic field in the core of the transformer. When this magnetic field cuts across the secondary winding, it produces alternating voltage in the coil. If the secondary winding is connected to a circuit, the output voltage causes alternating current to flow through the circuit.

The ratio between a transformer's output voltage and input voltage equals the ratio of the number of turns in the secondary winding to the number in the primary winding. If E represents the voltage and N stands for the number of turns, then $\frac{E\text{ output}}{E\text{ input}} = \frac{N\text{ secondary}}{N\text{ primary}}$. The output voltage will be greater than the input voltage in a transformer whose secondary winding has more turns than the primary winding. Such a transformer is called a *step-up transformer*. If the secondary coil has fewer turns than the primary, the output voltage will be less than the input voltage. This type of transformer is called a *step-down transformer*.

In power plants, step-up transformers increase the voltage of the alternating current produced by generators. High voltages make it possible to transmit the current over long distances with only a small loss in power. When the current reaches the area where it will be used, step-down transformers lower the voltage to the level needed by local consumers (see **Electric power** [Transmitting and distributing electric power]).

Some transformers have special uses. For example, *air-core transformers* and *powdered iron-core transformers* are designed to handle high-frequency alternating currents. *Instrument transformers* are used in measuring extremely large alternating voltages and currents. *Variable transformers* vary the amount of output voltage delivered to a circuit.

See also **Induction coil.**

Transfusion, Blood. See **Blood transfusion.**

Transistor is a tiny device used in computers, radios, television sets, and other electronic equipment. Transistors control the flow of electric current in such equipment. A typical transistor, together with its protective case, is about as large as the eraser on a pencil.

Electronic equipment has been revolutionized by transistors. In modern electronic equipment, most transistors are packaged inside devices called *integrated circuits*. There may be hundreds of thousands of transistors in just one integrated circuit about the size of a postage stamp (see **Integrated circuit**). Without transistors, manufacturers could not make pocket calculators or high-speed computers. Battery-operated radios and television sets would be much larger and cost more to operate. The small size and light weight of transistors also led to the development of communications satellites that link continents through telephones and television.

How transistors are made. Manufacturers make transistors from silicon, which is a solid material called a *semiconductor.* Semiconductors conduct electricity, but not so well as do true conductors, such as copper or iron. The atoms of the semiconductor material used in a transistor must be in the form of crystals.

Transistor manufacturers add small amounts of certain impurities to the crystals of the semiconductor. The impurities control the way electricity flows in the silicon. Some impurities add *free* (extra) electrons to the crystals. Other impurities do not supply the crystals with enough electrons. This lack of electrons causes empty spaces, known as *holes,* in the crystals. A semiconductor material is called *n-type* if it has extra electrons, and *p-type* if it has holes. Electricity flows as a movement of electrons in n-type material and as a movement of holes in p-type material.

Transistors consist of layers of n-type and p-type materials. To make a transistor, manufacturers may *grow* (make) pure crystals and cut them into thin slices. They heat these slices and expose them to impurities to form n-type and p-type layers. They then attach wires to the layers. Finally, the finished transistor is put into a tiny case to protect it.

How transistors work. There are two main types of transistors—*junction transistors* and *field-effect transistors.* Each works in a different way. But the usefulness of any transistor comes from its ability to control a strong current with a weak voltage. For example, transistors in a public address system *amplify* (strengthen) the weak voltage produced when a person speaks into a microphone. The electricity coming from the transistors is strong enough to operate a loudspeaker, which produces sounds much louder than the person's voice.

Junction transistors. A junction transistor consists of a thin piece of one type of semiconductor material between two thicker layers of the opposite type. For example, if the middle layer is p-type, the outside layers must be n-type. Such a transistor is an *NPN transistor.* One of the outside layers is called the *emitter,* and the other is known as the *collector.* The middle layer is the *base.* The places where the emitter joins the base and the base joins the collector are called *junctions.*

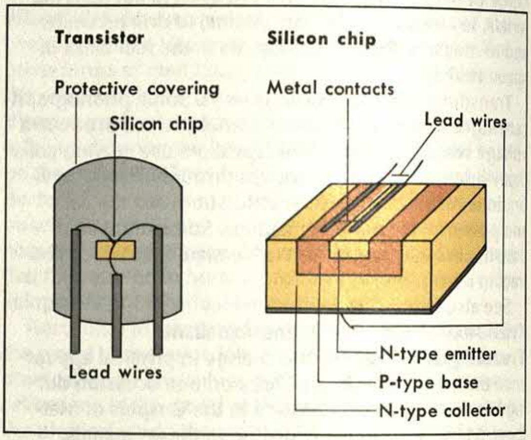
The layers of an NPN transistor must have the proper voltage connected across them. The voltage of the base must be more positive than that of the emitter. The voltage of the collector, in turn, must be more positive than that of the base. The voltages are supplied by a battery or some other source of direct current.

The emitter supplies electrons. The base pulls these electrons from the emitter because it has a more positive voltage than does the emitter. This movement of electrons creates a flow of electricity through the transistor.

The current passes from the emitter to the collector through the base. Changes in the voltage connected to the base modify the flow of the current by changing the number of electrons in the base. In this way, small changes in the base voltage can cause large changes in the current flowing out of the collector.

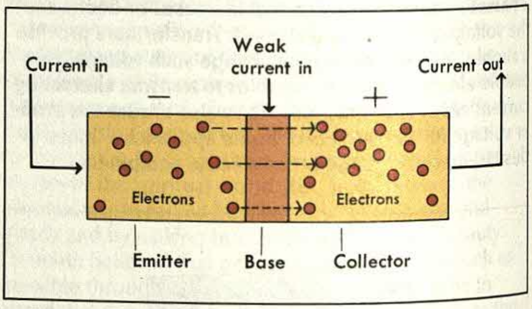
Parts of a transistor

An NPN junction transistor, shown on the lower left, consists of a tiny silicon chip in a protective case. The chip has a layer of one type of material between two layers of the opposite type, as shown in the cross-section drawing on the lower right. Lead wires are attached to each of these layers by metal contacts.



How a transistor works

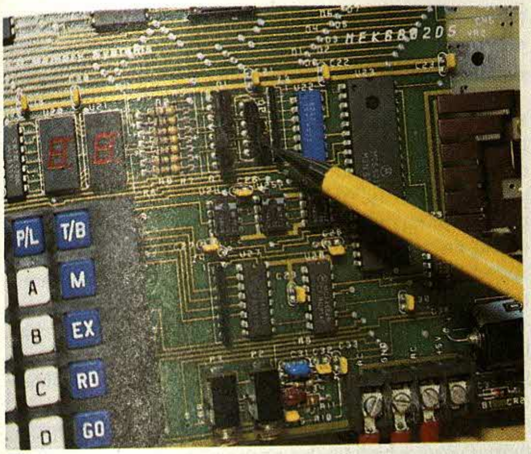
The emitter of an NPN transistor has a negative voltage and produces electrons. The collector has a positive voltage and attracts the electrons. A weak current applied to the base enables the electrons to move across the base from the emitter to the collector and create a flow of electricity. The weak base current controls the main flow of current through an NPN transistor.



Manufacturers also make *PNP junction transistors.* In these devices, the emitter and collector are both a p-type semiconductor material and the base is n-type. A PNP junction transistor works on the same principle as an NPN transistor. But it differs in one respect. The main flow of current in a PNP transistor is controlled by altering the number of holes rather than the number of electrons in the base. Also, this type of transistor works properly only if the negative and positive connections to it are the reverse of those of the NPN transistor.

Field-effect transistors. A field-effect transistor has only two layers of semiconductor material, one on top of the other. Electricity flows through one of the layers, called the *channel.* A voltage connected to the other layer, called the *gate,* interferes with the current flowing in the channel. Thus, the voltage connected to the gate controls the strength of the current in the channel.

There are two basic varieties of field-effect transistors—



Individual transistors occupy little space. In this photograph of a computer circuit board, a pencil points to a transistor.

the *junction field-effect transistor* (JFET) and the *metal-oxide semiconductor field-effect transistor* (MOSFET). Most of the transistors contained in today's integrated circuits are MOSFET's.

History. Three American physicists—John Bardeen, Walter H. Brattain, and William Shockley—invented the transistor in 1947. They shared the 1956 Nobel Prize for physics for their work. The first transistor was called a *point-contact transistor.* In 1948, Shockley developed the theory of the junction transistor. Within a few years, junction transistors had replaced the point-contact type. In 1952, Shockley published the theory that led to the field-effect transistor.

During the early 1960's, manufacturers developed the technique of making many transistors on a single piece of semiconductor material. This technique led to the development of integrated circuits on one piece of semiconductor material. Since that time, researchers have learned how to put ever increasing numbers of transistors and other components on each semiconductor chip. They have thereby reduced the average cost per transistor to a small fraction of what it was in the early 1960's. This technique has also greatly reduced the labour required to build complex equipment.

See also **Electronics; Semiconductor.**

Transistor radio. See **Radio** (diagram: Main parts of an AM/FM transistor radio).

Transit, in astronomy, is the crossing of one heavenly body over the disc of a larger one, as seen from the earth. The transits of Venus and Mercury have been studied with much interest because they can be used to determine the size of the solar system. The orbits of these planets are between the sun and the earth's orbit. Mercury passes directly between the sun and earth at intervals of from 3 to 13 years. It then appears as a black spot against the sun. Transits of Venus are much rarer, occurring in pairs every 122 years.

The term *transit* also means the passage of any celestial body, such as sun, moon, planet, or star, across an observer's meridian.

See also **Mercury** (Phases).

Transit. See **Surveying.**

Transjordan. See **Jordan.**

Transkei was a region on the southeastern coast of the Republic of South Africa. Until 1994, it was one of the 10 *homelands* established by the white South African government for the country's *African* (black) people. The Transkei was the homeland of the Xhosa people.

Transkei became part of South Africa in 1910. In 1959, the South African government established a policy of granting independence to the homelands. The Transkei was granted limited self-government in 1963. In 1976, the Transkei became the first homeland to be declared an independent nation by the government. In 1994, a new constitution abolished homelands in South Africa, and the Transkei ceased to exist.

See also **Apartheid; South Africa; Xhosa.**

Transmigration of the soul. See **Reincarnation.**

Transmission is a series of parts that transmit power from the engine of a motor vehicle. The power goes from the engine to the *drive shaft,* which carries it to the *final drive.* The power is delivered by the final drive to the vehicle's drive wheels. The transmission, drive shaft, and final drive make up the *drive train.* Cars, trucks, buses, bulldozers, and other motor vehicles have drive trains. This article discusses drive trains of cars.

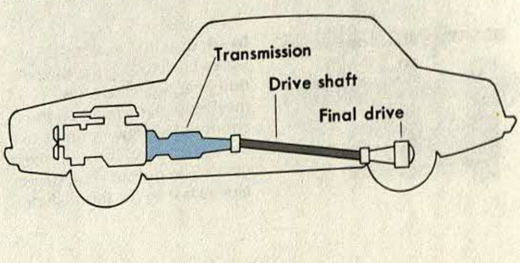
The diagram on this page shows the drive train of what car manufacturers call a *conventional car.* Conventional cars have the engine in front and the drive wheels in the rear. The parts of the drive train are arranged differently in cars that have a front-wheel drive or a rear-mounted engine. There are two main kinds of transmissions, *manual* and *automatic.*

What a transmission does

The power of an engine consists of *torque* and *speed.* Torque is the twisting force of the engine's crankshaft. Speed refers to the rate of rotation of the crankshaft. The transmission can adjust the proportions of torque and speed that it delivers from the engine to the drive shaft. When it increases the torque, it decreases the speed; and when it increases the speed, it decreases the torque. Thus, the transmission provides the high torque and low speed that a car needs to start moving. It also delivers the low torque and high speed needed for cruising on a motorway. The transmission also reverses the torque so a car can reverse.

Almost all transmissions vary torque and speed by means of *gears.* A gear is a wheel with projections called *teeth* around the edge. The teeth fit together with the teeth of another gear. Suppose that a small gear with 12 teeth drives a large gear with 24 teeth. The large gear rotates with half the speed, but twice the torque, of the small gear. This relationship is called *reduction.* The amount of reduction is expressed by the *gear ratio.* The gear ratio in the above example is 2 to 1, as the small

Parts of a drive train



gear rotates twice for each rotation of the large gear.

The gears in a transmission can be combined in different ways to produce various gear ratios and thus various proportions of torque and speed. The gear ratios are often called simply *gears* or *speeds.* Switching from one gear ratio to another is called *changing gears.*

How a manual transmission works

The driver changes the gears of a manual transmission by means of a hand-operated lever called a *gear lever.* Most manual transmissions have a neutral position; three, four, or five forward gears; and a reverse gear. The driver puts the transmission into neutral when the engine is being started, or when a car is parked with the engine left running.

To put a car into forward motion, the driver changes into *first,* or *low gear.* This gear provides the highest torque and the lowest speed. As the car picks up speed, the driver changes into *second gear,* then into *third gear,* and so on, until the transmission is in the highest gear desired. If extra torque is needed, the driver may change from a higher gear to a lower one. This situation might occur when the car goes up a steep hill. The reverse gear is used to make the car go backward.

The clutch. The driver of a car with a manual transmission must operate the *clutch* along with the gear lever. The clutch, which is operated by a pedal, connects the engine to the transmission. When the driver presses the pedal, the clutch is *disengaged* (disconnected from the engine), and no power is sent to the transmission. When the pedal is released, the clutch is *engaged,* sending power to the transmission. The clutch must be disengaged when changing gears.

The clutch consists basically of two discs, the *flywheel* and the *clutch plate.* The flywheel is connected to the crankshaft and turns whenever the engine is running. The clutch plate is connected to the *input shaft,* which leads to the transmission. When the clutch is engaged, springs press the clutch plate against the flywheel. Friction forces the two discs to turn at the same speed. When the clutch is disengaged, the springs are released and the discs separate.

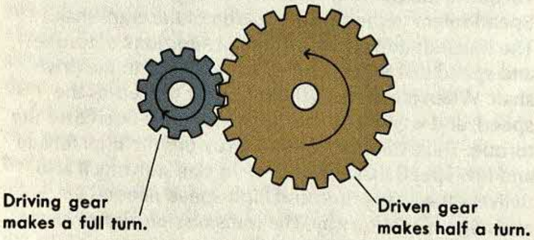
The gears. Power travels to the transmission through the input shaft. A gear at the end of this shaft drives a gear on another shaft called the *countershaft.* A number of gears of various sizes are mounted on the countershaft. These gears drive other gears on a third shaft, the *output shaft,* which leads to the drive shaft.

The transmission produces various gear ratios by engaging different combinations of gears. Only one combination can be engaged at a time. In a typical three-speed transmission, first gear has a ratio of 3 to 1; second gear, 2 to 1; and third gear, 1 to 1. Some four- and five-speed transmissions have a high-gear ratio of less than 1 to 1. For reverse, an extra gear called an *idler* operates between the countershaft and the output shaft. This extra gear turns the output shaft in the opposite direction of the input shaft, making the car go backward.

In early manual transmissions, gears became engaged by sliding along the output shaft until they

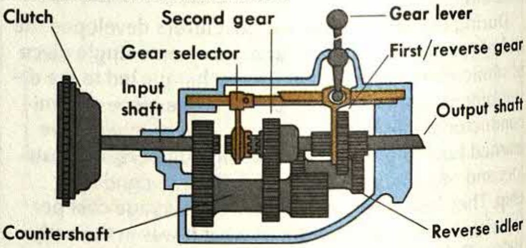
How a manual transmission works

What gears do


Driving gear makes a full turn.
Driven gear makes half a turn.

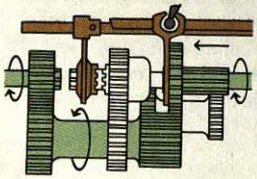
Reduction occurs when a small gear drives a large one, *above.* The driving gear makes a full turn for each half turn of the driven gear. Thus, speed is cut in half and torque is doubled.

Parts of a manual transmission

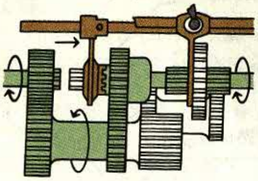


A manual transmission contains a system of gears controlled by a gear lever. A clutch connects it to the engine. When the transmission is in neutral, *above,* no power is transmitted.

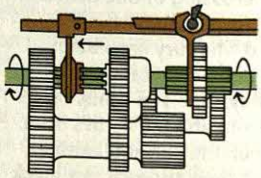
What happens when gears are changed



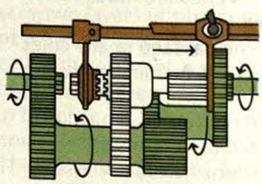
In first, or low, gear, the first/reverse gear slides forward and meshes with its mate on the countershaft. Power (green) flows to the output shaft through these gears. The output shaft turns a third as fast as the input shaft.



In second, the gear selector slides back to engage the second gear, which always meshes with its mate on the countershaft. Power flows to the output shaft through these gears. The output shaft turns half as fast as the input shaft.



In third, or high, the gear selector slides forward and connects the output shaft to the input shaft. Power flows directly through the two shafts. No reduction occurs, and the output shaft turns at the same speed as the input shaft.



In reverse, the first/reverse gear slides back and meshes with the reverse idler. The idler, an extra gear, turns the output shaft in the opposite direction to the input shaft, thus making the vehicle go backward.

meshed with their mates on the countershaft. The gears often clashed because they turned at different speeds when they were being meshed. Most modern transmissions overcome this problem by having their forward gears always meshing. When these gears are not engaged, they turn freely on their shaft. They are engaged by a mechanism, called a *synchronizer,* which slides against a gear and locks it onto its shaft. The synchronizer forces the gear and the shaft to rotate at the same speed before locking them together.

How an automatic transmission works

An automatic transmission contains special devices that automatically provide various gear ratios as they are needed. Instead of a gear lever, the driver operates a lever called a *selector.*

Most automatic transmissions have selector positions for *park, neutral, drive, low,* and *reverse.* The engine can be started only if the selector is in either the park or neutral position. In park, the drive shaft is locked so that the drive wheels cannot move. For ordinary driving, the driver moves the selector to the drive position. The transmission starts out in the lowest gear and automatically changes into higher gears as the car picks up speed. The driver uses the low position for going up or down steep hills or driving through snow or mud. When in low, the transmission remains in the lowest gear. Some transmissions have a position between low and drive. This prevents the transmission changing above second gear.

During the late 1980's, several car manufacturers began to install a kind of automatic transmission called a *continuously variable transmission* (CVT) in subcompact vehicles. Instead of gears, this transmission uses two pairs of cone-shaped pulleys connected by a metal belt. The ratio of the rotations, often called the gear ratio, is determined by how far the belt rides from the centres of the pulleys. Thus, the CVT can produce an unlimited number of ratios. As the car changes speed, the CVT continuously adjusts the ratio. Cars with a CVT use fuel more efficiently.

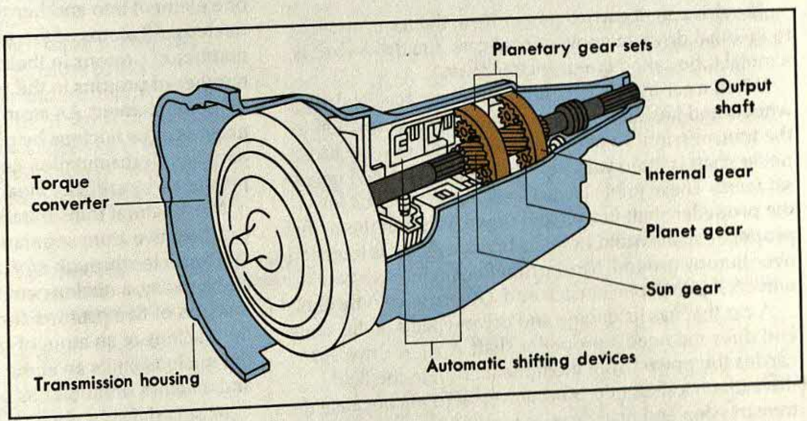
The torque converter is a device that most automatic transmissions have instead of a clutch. A torque converter delivers power from the engine to the transmission and also increases the torque.

A torque converter resembles a large doughnut sliced in half. One half, called the *pump impeller,* is bolted to the flywheel. The other half, called the *turbine,* is connected to the transmission input shaft. Each half is lined with *vanes* (blades). The pump and the turbine face each other in a case filled with oil. A bladed wheel called a *stator* is between them.

The engine drives the pump. As the pump rotates, it throws oil against the vanes of the turbine. The force of the oil tends to make the turbine rotate and send power to the transmission. After striking the turbine vanes, the oil travels back to the pump, passing through the stator. When the pump turns much faster than the turbine, torque is increased. A complex reaction between the oil and the stator creates the increase in torque.

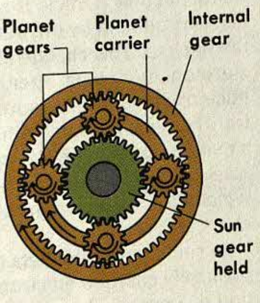
Parts of an automatic transmission

The diagram on the right shows a typical automatic transmission. It contains a *torque converter* rather than the clutch used in a manual transmission. It also has two sets of *planetary gears.* Some automatic transmissions have only one set of these gears. Special devices in the transmission change the gears automatically.

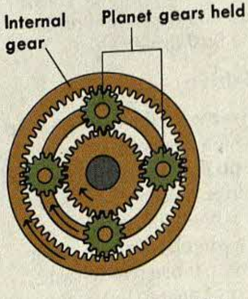


How planetary gears work

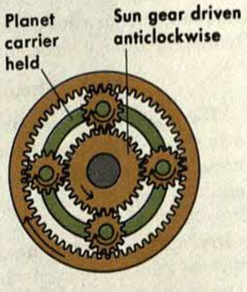
The parts of a planetary gear set can be held from turning or locked together to achieve a variety of gear ratios. The illustrations on the right show a few possible combinations. In all three cases, the internal gear is driving the other parts of the gear set. The effects can be multiplied by two gear sets arranged in line.



Reduction. Sun gear held. Planet gears "walk" around sun gear, causing planet carrier to rotate more slowly than internal gear.



Direct drive. Internal gear and planet carrier locked together. Planet gears cannot turn. Entire gear set rotates as a unit.



Reverse. Planet carrier held. Internal gear rotates clockwise. Planet gears turn and act as idlers. Sun gear driven anticlockwise.

When the engine is running slowly, the oil may not have enough force to rotate the turbine. But when the driver presses the accelerator pedal, the engine runs faster and so does the pump. The action of the pump increases the force of the oil. This force gradually becomes strong enough to rotate the turbine—and move the car. The fluid action reduces efficiency because the pump tends to rotate faster than the turbine. To improve efficiency, many transmissions include a *lock-up clutch.* When the pump reaches a specific rate of rotation, this clutch locks the pump and turbine together, allowing them to rotate as one.

The planetary gears are special gears that are part of most automatic transmissions. A set of planetary gears consists of three elements. The first element is a *sun gear,* located in the centre. The second element, called a *carrier,* surrounds the sun gear. The carrier holds two, three, or four *planet gears,* which mesh with the sun gear and revolve around it, much as the planets travel around the sun. The third element is an *internal gear,* a ring with teeth on the inside. It surrounds the planet gears and meshes with them.

Any element of a set of planetary gears can be held stationary, or locked to one of the others, to produce different gear ratios. Most automatic transmissions have two sets of planetary gears arranged in line. The gears are changed inside the transmission by a system of automatic devices which are controlled by the position of the selector, the speed of the car, and other factors.

The drive shaft

The drive shaft carries power from the transmission to the final drive. In conventional cars, the drive shaft is a metal tube called the *propeller shaft.*

When a car travels over an uneven surface, its drive wheels and final drive move up and down in relation to the transmission. To allow for this movement, the propeller shaft is fitted with flexible couplings called *universal joints.* These joints have a wristlike action that lets the propeller shaft flex up and down. Without them, the propeller shaft would bend or break as the car travelled over bumpy ground. Most propeller shafts have two universal joints, one at each end. Others have only one.

A car that has its engine and drive wheels at the same end does not need a propeller shaft. A short drive shaft carries the power from the transmission to the final drive. Such a shaft needs no universal joints because the transmission and final drive are bolted together. Universal joints on the axles permit up-and-down motion between the drive wheels and the final drive.

The final drive

The final drive transmits power from the drive shaft to axle shafts connected to the drive wheels. In a conventional car, the propeller shaft and the axle are at a right angle to each other. The final drive must carry power through this angle to drive the wheels. In addition to carrying the power to the drive wheels, the final drive divides the torque evenly between those two wheels. The final drive contains two sets of gears: (1) the ring gear and pinion and (2) the differential.

The ring gear and pinion are *bevel gears*—that is, they mesh at a right angle to each other. Thus, they carry power through a right angle to the drive wheels. The ring gear is driven by the pinion, which receives power from the propeller shaft.

In most cars, the ring gear is two to four times as large as the pinion. Therefore, these gears reduce the speed from the propeller shaft and increase the torque. The reduction in the final drive multiplies the reduction that has taken place in the transmission. For example, suppose a car has a first-gear ratio of 3 to 1 and a final-drive ratio of 3 to 1. The total reduction is 9 to 1. In other words, when in first gear, the engine crankshaft rotates 9 times for each rotation of the drive wheels.

Some cars have a *transverse* engine, which is mounted across the car and between the drive wheels. In such cars, the power of the engine does not have to be carried through a right angle to the drive wheels. Therefore, the final drive contains ordinary reducing gears rather than a ring gear and pinion.

The differential is a set of gears that divide the torque evenly between the two drive wheels. The differential also enables one wheel to rotate faster than the other. For example, when a car goes around a corner, the outside drive wheel travels farther than the inside one. The outside wheel must rotate faster than the inside one to cover the greater distance in the same time.

See also **Car** (The drive train; illustrations); **Gear.**

Transmitter. See **Radio** (How radio works; pictures: Building a radio transmitter); **Telephone** (How a telephone works); **Television** (Transmitting television signals).

Transmutation of elements is the conversion of one element into another through changes in an atom's nucleus. All atoms of the same element have the same number of protons in their nuclei. Any change in the number of protons in the nucleus produces an atom of a different element. An atom can change the number of protons in its nucleus by giving off or taking in atomic particles. Transmutation can occur naturally or it can be produced by artificial means.

Most natural transmutations occur when a nucleus of a radioactive atom spontaneously *emits* (gives off) certain particles through *alpha decay* or *beta decay.* In alpha decay, a nucleus emits an alpha particle, which consists of two protons and two neutrons. For example, the nucleus of an atom of radium has 88 protons. After the nucleus emits an alpha particle, 86 protons are left and an atom of radon has been formed.

In beta decay, a nucleus emits a beta particle. In most cases, the beta particle is a negatively charged electron that is produced by the transformation of a neutron in the nucleus. This change also results in the formation of a proton. As a result, after it emits the beta particle, the nucleus contains one more proton and one less neutron. For example, an atom of the isotope carbon 14 has a nucleus containing six protons and eight neutrons. After the nucleus emits a beta particle, nitrogen 14, which has seven protons and seven neutrons in its nucleus, is formed.

In some cases, the beta particle is a *positron.* This positively charged electron is formed by the transformation of a proton. A neutron is formed at the same time. After it emits a positron, a nucleus has one less proton and one more neutron. For example, carbon 11, which has six protons and five neutrons, emits positrons. After a carbon 11 nucleus emits a positron, an atom of boron

11—which has five protons and six neutrons—is formed.

Most artificial transmutations are produced by bombarding nuclei with alpha particles or other high-energy particles in a nuclear reactor or a particle accelerator (see **Particle accelerator**). In a transmutation produced using alpha particles, a nucleus gains a proton and two neutrons. The nucleus first absorbs the alpha particle, which contains two protons and two neutrons. However, the nucleus formed by this absorption is unstable, and it ejects a proton.

Processes called *fission* and *fusion* also produce transmutation. Fission occurs when the nucleus of an atom splits into the nuclei of two lighter elements. In most cases, such splitting is caused by the absorption of a neutron by the nucleus. Fusion results from the joining of the nuclei of two lighter elements to form the nucleus of a heavier element. See **Fission; Fusion.**

See also **Radioactivity; Transuranium element.**

Transnational corporation. See **Multinational corporation.**

Transpiration is the giving off of water by the leaves of a plant. Plants give off water chiefly through tiny pores called *stomata* on the surface of the leaves. The amount of water they give off depends somewhat upon how much water the roots of the plant have absorbed. The amount given off also depends upon such environmental conditions as sunlight, humidity, winds, and temperature. A plant should not be transplanted in full sunshine because it may lose too much water and wilt before the damaged roots can supply enough water.

See also **Leaf** (Transpiration).

Transplant, in medicine. See **Tissue transplant.**

Transplanting, in gardening, is the process of removing a plant from one place and planting it in another. Many plants are started from seeds in protected areas, such as greenhouses and hotbeds, where growing conditions are ideal. When the seeds have grown into seedlings, the seedlings are transplanted to a garden. Seeds grown this way have a better chance of sprouting and will sprout more quickly than those planted outdoors. In addition, transplanting enables gardeners to space the seedlings properly in the ground. Plants also may be transplanted from one place in a garden to another. House plants are transplanted by a process called *repotting* (see **Gardening** [Cultivating an indoor garden]).

Seedlings for transplanting are grown by planting seeds in shallow wooden boxes called *seed trays,* or in individual containers. Plants for transplanting are also produced by using cuttings from the stems of older plants. Gardeners usually transplant seedlings two to three weeks after the seeds have sprouted. If seedlings are transplanted when they have grown bigger, their disturbed root system will not be able to supply enough water to the large leaves and stem. The seedlings should be watered several hours before transplanting to reduce the danger of fatal water loss.

Gardeners transplant a seedling by carefully digging underneath its roots and lifting it out. The seedling is immediately replanted in its new location, with the soil pushed firmly around it. If the roots are allowed to lie in the sun, they will dry out and the plant will die. The seedling should be watered as soon as it has been replanted. Gardeners may transplant seedlings with or without soil attached to the roots. Older plants should always be transplanted with a ball of soil around the roots.

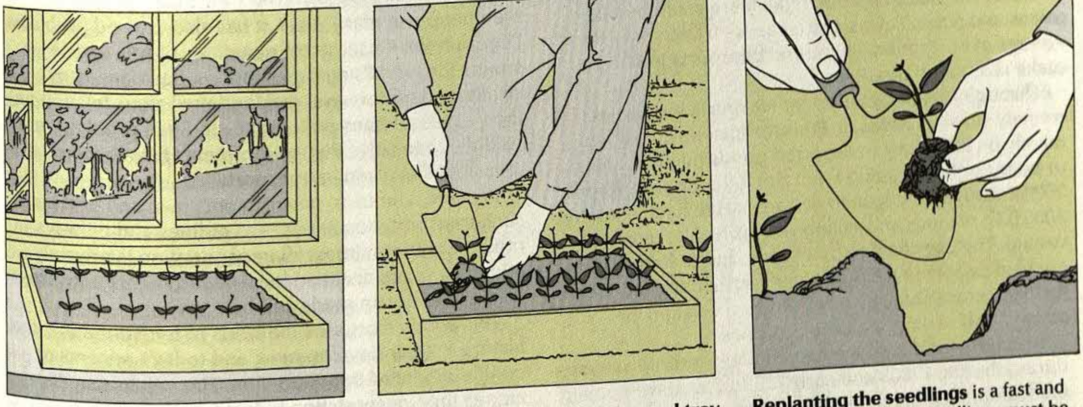
Transplanting seedlings from an indoor protected area to an outdoor garden is a shock to the system of the plants. To decrease this shock, gardeners place the seed tray outdoors in a warm, sheltered area, such as a cold frame, for several days before transplanting the seedlings.

See also **Cold frame; Gardening; Hotbed; Nursery; Tree** (Planting the tree).

Transport. See **Transportation.**

Steps in transplanting seedlings

Transplanting involves removing a plant from one place and planting it in another. Many plants are started indoors and then transplanted to a garden after the seeds have grown into seedlings. When transplanting the seedlings, gardeners follow several steps to prevent injury to the plants.



Growing the seedlings indoors protects them from harsh conditions outside. Seedlings are often grown in *seed trays.* Seed trays are placed in sunny areas only after the seeds have sprouted.

Removing the plants from a seed tray involves carefully digging around the roots and lifting out the seedlings. The seedlings should be watered several hours before they are removed.

Replanting the seedlings is a fast and delicate process. The seedlings must be replanted quickly so the roots do not dry out, and they must be handled gently so they are not damaged.

Motor vehicles on a motorway junction

Passengers alighting from a transoceanic airliner

A ship passing through the Panama Canal

Modern transportation involves the use of engine-powered vehicles, such as those pictured above and on the next page. Fast, dependable transportation is essential to the economy and way of life in industrially developed countries.

Transportation

Transportation is the act of moving people or goods from one place to another. Transportation takes people where they need or want to go, and it brings them the goods they need or want. Without transportation, there could be no trade. Without trade, there could be no towns and cities. Towns and cities are traditionally the centres of civilization. Therefore, transportation helps make civilization possible.

Throughout most of history, transportation was extremely slow and difficult. Prehistoric people travelled mainly on foot. They transported goods on their backs or heads or by dragging them along the ground. About 5000 B.C., people began to use animals to haul loads. By 3000 B.C., wagons and sailing vessels had been invented. The use of animals, wagons, and sailing vessels enabled people to transport loads farther and more easily than before. But the speed of transportation improved only slightly over the centuries.

Inventors produced the first engine-powered vehicles during the late 1700's and early 1800's. This development marked the beginning of a revolution in transportation that has continued to the present. Today, jet airliners carry travellers nearly as fast as, or faster than, the speed of sound. Trains, trucks, and giant cargo ships carry a steady flow of goods to buyers in almost all parts of the world. Cars and buses provide convenient transportation for many millions of people.

Although engine-powered transportation has benefited people in many ways, it has also created problems. For example, it uses great quantities of fuel and so strains the world's energy supplies. Cars jam many streets and motorways, making travel slow. In addition, their exhaust fumes pollute the air. Such problems are so difficult to solve that governments have become increasingly involved in transportation.

In some countries, governments own and operate such transportation services as airlines and railways. In other countries, almost all transportation is privately owned, and national and local governments only provide and maintain roads and bridges.

This article discusses the kinds of transportation, the history of their development, and today's systems of engine-powered transportation. The article also discusses the transportation industry and current developments in transportation. Vehicles are also used for recreation, warfare, and space exploration. These uses are described in such articles as **Air force**, **Balloon**, **Boating**, **Navy**, and **Space exploration**.

A snowmobile in the far north

A train stopped in an underground station

A hydrofoil ferrying passengers across a bay

School buses ready to take children home

Kinds of transportation

There are three main kinds of transportation: (1) land, (2) water, and (3) air. Land transportation depends mainly on wheeled vehicles, especially cars, buses, trains, and trucks. Ships and boats are the most important water vehicles. Air transportation depends almost entirely on aeroplanes.

Each kind of transportation can further be classified according to whether the vehicles are engine powered or engineless. Most engine-powered vehicles have petrol, diesel, or jet engines. The majority of engineless vehicles are powered by the muscles of human beings or animals or by natural forces, such as the wind or flowing water.

Engine-powered transportation has many advantages over engineless transportation. It is usually faster, more dependable, and can carry far greater loads. However, such transportation is costly. Engine-powered vehicles are expensive to build, and need regular servicing during their period of service. In most cases, each type of vehicle also requires certain *supporting facilities.* Cars and trucks require roads. Trains must have tracks. Aeroplanes require airports. Ships need ports and harbours. All these facilities are expensive to build and maintain. Every form of engine-powered transportation also requires a source of energy. The combined cost of the vehicles, supporting facilities, and energy makes engine-powered transportation extremely expensive.

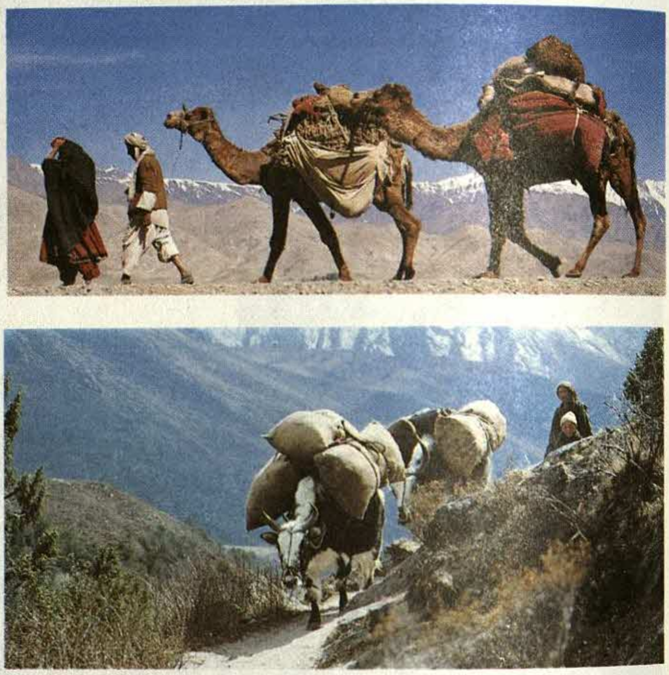
Engine-powered vehicles are the chief means of transportation in industrially developed countries. Engine-powered vehicles also provide transportation in the urban areas of most developing countries, including the African, Asian, and Latin American nations. However, many people who live in rural areas of these countries still rely on the kinds of engineless transportation their ancestors used hundreds or thousands of years ago.

Land transportation is the most common kind of transportation by far. In many cases, it is the only suitable or available form of transportation.

Engine-powered land transportation. Buses, cars, motorcycles, snowmobiles, trains, and trucks are the chief engine-powered land vehicles. All these vehicles except snowmobiles ride on wheels. Pipelines are another important form of engine-powered transportation used over land (and sometimes over the sea bed).

Cars, buses, and trucks are the main modern road vehicles. In areas well served by roads, they can provide a variety of transportation services. Cars enable people to

An age-old method of transportation is the hauling of goods by people themselves. These women in Burma are carrying bricks on their heads to other workers at a construction site.



Pack animals are used to transport goods in many mountainous regions, deserts, and other areas that lack modern roads. In Afghanistan, nomads use camels as beasts of burden, *above top.* In Nepal, Asian oxen called *yaks* carry goods through the high, rugged passes of the Himalaya, *above bottom.*

travel whenever and by whatever route they choose. Buses carry passengers along fixed routes between and within cities. Trucks can provide door-to-door freight service. Many people ride motorcycles, mopeds, or motor scooters to and from work.

Unlike road vehicles, trains ride on tracks. As a result, trains usually cannot provide door-to-door freight service like trucks or convenient connecting passenger services like buses. But trains can haul far heavier loads than trucks can. They can also carry many more passengers than buses can.

Snowmobiles skim across ice or snow. The vehicles have two skis at the front and a moving track at the rear. An engine powers the track, which propels the vehicle. People use snowmobiles for transportation mainly in far northern regions that are snow-covered during much of the year.

Pipelines provide transportation, but the pipes themselves do not move. Most pipelines are built across land, but some span rivers or other bodies of water. Pipelines transport chiefly liquids and gases, especially petroleum and natural gas. Engine-powered pumps force the liquid or gas through the pipes.

Engineless land transportation. Walking is the most elementary means of transportation. Carrying a load on one's back or head or using animals to carry loads is also elementary. Animals used for this purpose are called *pack animals* or *beasts of burden.* They include camels, donkeys, elephants, horses, llamas, and oxen. People use pack animals mainly in regions that lack modern roads. Such regions include many deserts, mountainous areas, and jungles.

People use their muscle power to move such wheeled vehicles as carts, bicycles, and pedicabs. A cart is a small box-shaped vehicle with two or four wheels and an open top. A person may either push or pull a cart, whichever is more convenient. Bicycles are two-wheeled vehicles that the rider powers by means of two pedals. Many people in European and Asian countries ride bicycles to and from work. A pedicab resembles a bicycle but has two rear wheels instead of one. It also has a passenger carriage at the front or rear. Pedicabs are used as taxicabs and even as school buses in some Asian countries.

Animal-drawn carts and wagons are a major means of transportation in rural areas of many developing countries. Carts may be pulled by dogs, donkeys, horses, or oxen. Wagons are large four-wheeled carts that can carry heavy loads. Therefore, they must be pulled by exceptionally strong animals, such as oxen or draught horses.

Water transportation depends mainly on boats, ships, and rafts. Any small watercraft is classed as a boat. People use boats chiefly on rivers, canals, and lakes. A ship is a larger vessel sturdy enough for ocean travel. A raft is a floating platform constructed of such materials as logs or barrels.

Engine-powered water transportation. Nearly all ships and many boats are powered by engines. Most ships specialize in carrying cargo. Cargo ships travel mainly on ocean waters and on bodies of water linked to the ocean, such as the Mediterranean Sea and the Baltic Sea. Some cargo ships operate on large inland waterways, such as the Great Lakes of North America.

Few ships specialize in transporting passengers. However, various types of motorboats carry passengers locally. Some engine-powered boats, especially tugboats, are used in hauling freight. Tugboats have powerful engines that enable them to tow heavily loaded barges. Barges are actually large rafts. Most barges must be pushed or towed. Others have engines and so move under their own power. Barges are used mainly to haul freight along inland waterways.

In general, ships and boats are the slowest engine-powered vehicles. However, engineers have developed two fast-moving water vehicles—*hydrofoils* and *hovercraft.* Hydrofoils skim across the water on skids or runners. Hovercraft, or *air cushion vehicles,* ride above the water on a cushion of air. One or more powerful fans inside the vehicle create the air cushion. Because hydrofoils and hovercraft ride out of the water, they can travel faster than other watercraft of equal enginepower. Most hydrofoils and hovercraft are too small for ocean travel. They are used mainly to carry passengers locally. Some larger hydrofoils and hovercraft are used to carry cargo along inland and coastal waters.

Engineless water transportation. Engineless water vehicles include dugouts, canoes, rowing boats, sailing boats, and rafts. People use paddles or oars to propel dugouts, canoes, and rowing boats. Sailing boats are powered by the wind. Rafts may be propelled by paddles, poles, sails, or water currents.

Broad-bottomed sailing boats and rowing boats are widely used to haul freight in the Far East. The sailing boats are called *junks,* and the rowing boats are known as *sampans.* Large junks have as many as five sails and can carry as much as 100 metric tons of freight. Most sampans carry light cargo. However, many larger sampans have a sail, which enables them to carry heavier loads. In the tropical rain forests of Africa, Asia, and South America, many villagers use dugouts or rafts for transportation along the rivers. Many people of the Pacific Islands use dugouts for travel between islands. Some of the dugouts are equipped with outriggers and sails.

Air transportation depends almost entirely on engine-powered craft, especially aeroplanes. Engineless vehicles, such as gliders and hot-air balloons, are used mainly for recreation.

Aeroplanes provide the world's fastest practical means of transportation. Only rocket-powered spacecraft travel faster. Big airliners cruise at 800 to 1,000 kilometres per hour (kph). Most private planes and some older airliners are powered by petrol engines and driven by propellers. Nearly all newer airliners and some private planes have jet engines. *Supersonic* jets fly faster than the speed of sound. These planes travel at about 2,400 kph. Most airliners chiefly carry passengers. Even the biggest planes can carry only a fraction of the weight that a ship or train can transport. Air freight rates are high as a result. The high cost limits the shipment of goods by air to expensive, lightweight, or perishable cargo. Such goods include electronic equipment and fresh flowers.

Helicopters, like aeroplanes, are powered by engines. But helicopters are smaller than most aeroplanes and cannot fly as fast or as far. Nor can they carry as many passengers as aeroplanes. Helicopters therefore play a secondary role in air transportation. However, they are much more manoeuvrable and have certain special uses. For example, helicopters are used in rescue work and in fighting forest fires.

History

Prehistoric times. Transportation developed slowly during prehistoric times, which lasted until about 3000 B.C. Throughout most of the period, people lived by hunting, fishing, and gathering wild plants. They had no beasts of burden, wheeled vehicles, or roads. People travelled on foot and carried their infants and belongings strapped to their backs or heads. Loads too heavy for one person to carry were strapped to a pole and carried by two people.

In time, prehistoric people learned that they could drag loads along the ground on *sledges.* They made sledges from logs, poles, rawhide, or anything else that could hold a load and be dragged by one or more persons. During late prehistoric times, people began to build sledges with runners. These vehicles slid along the ground more easily than runnerless sledges, especially if the runners were greased. In far northern regions, people built lightweight sledges with runners for use on snow and ice.

By about 8000 B.C., various Middle Eastern peoples had developed agriculture and begun to establish permanent settlements. Trade between settlements then started to develop, and this created a need for better means of transportation. The donkey and the ox, which had been *domesticated* (tamed) for farm work, helped meet this need. Between about 5000 and 3500 B.C., people began to use donkeys and oxen as pack animals. Next, they invented harnesses so that the animals could be used to pull sledges. The use of donkeys and oxen as beasts of burden enabled individuals to transport heavier loads than they could before.

People also began to develop water transportation during prehistoric times. They built rafts of such materials as logs or reeds. Later, prehistoric people learned how to make dugouts and canoes. All these early craft were propelled by paddles or poles and were used on streams and lakes. The craft were too fragile for ocean travel.

The wheel was invented about 3500 B.C. The invention probably took place in Mesopotamia, a region of the Middle East. The Egyptians invented sailing boats about 3200 B.C. During the following centuries, wheeled vehicles and sailing vessels revolutionized transportation.

The first great civilizations arose in Mesopotamia and Egypt between 3500 and 3000 B.C. From these two centres, civilization gradually spread westward along the shores of the Mediterranean Sea. Sailing vessels played a vital role in the spread of civilization. Sea voyagers transmitted the ideas and inventions of civilized cultures to less developed societies as they sailed the Mediterranean.

The early Mediterranean civilizations flourished from about 3000 to 500 B.C. During this period, improvements in sailing vessels and wheeled vehicles accounted for the chief advances in transportation.

Early development of sailing vessels. By 3000 B.C., the Egyptians had learned to build sailing vessels sturdy enough to put out to sea. Some of these ships ventured into the Mediterranean and Red seas on short trading journeys. Between 2000 and 1000 B.C., other Mediterranean peoples developed bigger and sturdier vessels. By 1000 B.C., the Phoenicians, who lived along the eastern shores of the Mediterranean Sea, had built a large fleet of merchant ships. The Phoenicians sailed the length of the Mediterranean, from their home waters to Spain. They traded everything from pottery to cattle for various other goods at ports along the shores of the Mediterranean.

Sea travel remained slow and difficult throughout ancient times. Sailors lacked navigation instruments. As a result, they usually stayed within sight of land. The ships were hard to steer because they had no rudder. Sailors steered their ships by means of one or two oars at the stern.

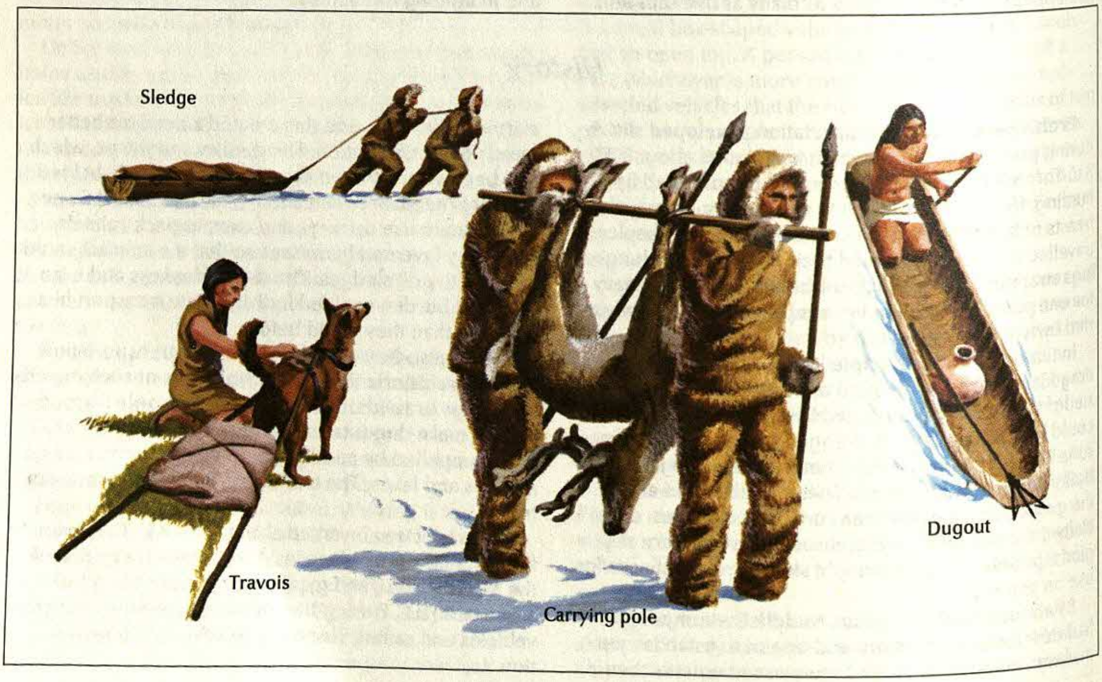
In addition, the ships could not depend entirely on the wind for power. The earliest ships had a single sail, which worked well only when the wind blew from behind. The sail did not work well in sailing against the wind. For times when there was no wind, many ships had teams of oarsmen to row the vessels.

Early development of wheeled vehicles. The use of logs as rollers to help move heavy loads may have led to the invention of the wheel. The Mesopotamians built the first known wheeled vehicles about 3500 B.C. But such vehicles were not widely used until after 3000 B.C. The technique of making wheels and wheeled vehicles slowly spread from Mesopotamia. It reached India about 2500 B.C., Europe about 1400 B.C., and China about 1300 B.C.

The first wheeled vehicles were four-wheeled carts. They were pulled by oxen or, after about 3000 B.C., by donkeylike animals called *onagers.* Each wheel on a cart was a wooden disc made from three rectangular boards. To construct a wheel, a wheelmaker fastened the boards together edge to edge with wooden braces to make a square. The square was then rounded at the corners to form the disc. The three-piece construction prevented the wheels from being perfectly round. The early carts bumped along at a snail's pace and probably had to be stopped frequently for repairs.

At first, the Mesopotamians used carts mainly as funeral cars. After about 3000 B.C., carts drawn by onagers carried Mesopotamian troops into battle. In time, carts were occasionally used to carry passengers and to haul grain, sand, and other goods that were difficult to load

Transportation in prehistoric times Nearly all the methods of transporting goods or people during prehistoric times depended on the muscles of either human beings or animals. Some of these methods are pictured below. Similar methods are still used in many parts of the world.



onto sledges or pack animals. However, wheeled vehicles could not compete with sledges and pack animals until the design of the wheels was improved.

Wheels continued to be made of three solid pieces of wood until about 2000 B.C. Between 2000 and 1500 B.C., the first spoked wheels appeared. These wheels consisted of a rim, a hub, and spokes. The three parts were constructed separately. Spoked wheels provided smoother riding than solid wooden wheels, and they were lighter and faster. The first spoked wheels were probably made for chariots.

Chariots with spoked wheels were light enough for horses to pull. Horses had been tamed for riding by about 2000 B.C. But they could not be used to pull heavy loads because a suitable harness had not yet been invented. The harnesses then in use pressed against a horse's windpipe. If a horse had to pull too heavy a load, the harness cut off the animal's breathing. However, two or more horses could pull a lightweight chariot easily. Horse-drawn chariots, used chiefly by warriors, became the swiftest vehicles of ancient times.

Ancient Greece. During the 400's B.C., Greece became the chief power in the Mediterranean area. The Greeks expanded the sea trade begun by the Phoenicians. They also pioneered the building of two-masted vessels and increased the number of sails from one to four.

Greek cargo ships sailed from home with huge jars of olive oil and wine. These products were exchanged for wheat and other grain at various ports on the Mediterranean and Black seas. The grain trade was extremely important to the Greeks. Wheat was the principal food during ancient times, and the Greeks had to import most of their supply. Many Greek grain ships were seized by enemy or pirate vessels. Many others sank in storms. But almost every year, enough ships returned home to prevent famine for another year.

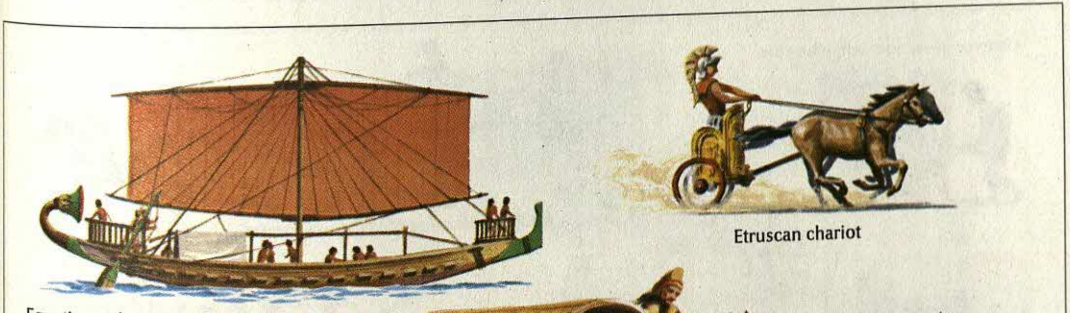
The ancient Greeks developed a highly advanced civilization. Greek merchant ships helped spread Greek civilization westward. As civilization spread, trade and shipping increased. By 400 B.C., about 300 ports lay on the Mediterranean and several thousand trading ships of various countries crisscrossed the sea.

Ancient Rome. From the 100's B.C. to the A.D. 400's, Rome ruled the mightiest empire of ancient times. At its peak, the Roman Empire included all the lands bordering the Mediterranean. It also extended as far north as the British Isles and as far east as the Persian Gulf. To help hold their vast empire together, the Romans built a highly advanced system of roads.

People had built roads long before Roman times. By about 1000 B.C., the Chinese had begun to construct roadways between their major cities. The Persians built a similar road network during the 500's B.C. But most of the early intercity roads were little more than dirt tracks. The Romans constructed the first extensive system of paved roads. The best Roman roads measured 5 to 6 metres wide and were from 1 to 2 metres thick. They had a base that consisted of several layers of crushed stone and gravel. The roads were paved with stone blocks.

The Romans used their roads chiefly to transport

Vehicles of ancient times Wheeled vehicles and sailing vessels were invented during the 3000's B.C. They became the most widely used means of transportation during ancient times. But many people also continued to use earlier forms of transportation, such as pack animals.



Egyptian sailing ship

Etruscan chariot

Scythian oxcart

Egyptian pack animals

troops and military supplies. But the roads also served as a major communications link between Rome and its provinces. Messengers in horse-drawn carts used the roads to carry government communications. By the A.D. 200's, more than 80,000 kilometres of paved roads connected Rome with almost every part of its empire.

During the 400's, Germanic tribes conquered most of the Roman territories in western Europe. The majority of Roman roads fell into ruin during the following centuries. However, a few are still used.

The Romans also built the largest fleet of cargo ships in ancient times. Like the Greeks, the Romans could not survive without sea trade. Roman cargo ships supplied the city of Rome with most of its grain supply.

The Middle Ages, which lasted from the 400's to the 1500's, brought great improvements in land and water transportation. These improvements resulted largely from three remarkable inventions—the rigid horse collar, the iron horseshoe, and the whiffletree. Scholars do not know exactly when or where these devices were invented. But all three had appeared in Europe by the end of the 1000's.

The rigid horse collar appeared about 800. Before this invention came into common use, horses wore a harness across the neck. The harness choked a horse if it pulled a heavy load. The rigid horse collar shifted the weight of a load to a horse's shoulders. Horses collared in this way could pull four or five times as much weight as before.

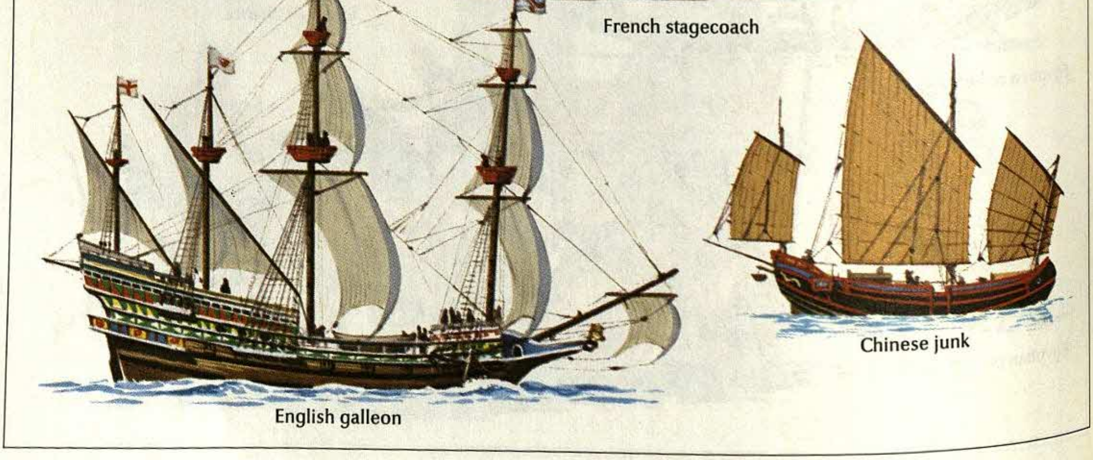
The iron horseshoe appeared in Europe about 900. Horses without shoes often suffered from damaged hoofs if they travelled long distances. Iron shoes protected a horse's hoofs from damage and so enabled the animal to travel farther and faster than it could without them.

The whiffletree, which appeared during the 1000's, made it possible for wagons to be pulled by teams of horses. A whiffletree is a pivoted crossbar at the front of a wagon to which a team's harnesses are fastened. It equalizes the pull of the horses. Without such a device, a wagon may be thrown off balance and may even be overturned.

The invention of the rigid horse collar, iron horseshoe, and whiffletree stimulated overland trade. They made it possible for horses to pull as much weight as oxen—and for longer distances and at twice the speed.

The increased speeds of horse-drawn vehicles also encouraged greater use of wagons for passenger transportation. But wagon rides were extremely bumpy. Wagon makers tried to correct this problem by building vehicles with *suspension systems,* which provided a certain amount of cushioning against bumps. However, only rich people could afford such vehicles. Most of the people of the Middle Ages travelled on foot or on horseback, just as people had done in the past.

The design and construction of ships improved greatly during the Middle Ages. The triangular *lateen sail* was used in Asia and the Mediterranean region in the 500's. Unlike square sails, which were widely used at the time, lateen sails could be positioned to work even when ships sailed into the wind. The first ships with a rudder rather than steering oars at the stern appeared in



Transportation in early modern times Beginning in the 1400's, Europeans built ships capable of making long ocean voyages. Stagecoaches became widely used in Europe during the late 1600's and early 1700's. In other parts of the world, such as China, people continued to use older forms of transportation.

Europe about 1300. Rudders could be used to steer much bigger ships than could be steered with oars. During the 1400's, shipbuilders began to produce ships four times as large as any built before. All these ships had a rudder, and most of them had three masts and at least three sails.

Navigational instruments were also developed during the Middle Ages. The *mariner's compass* allowed voyagers to navigate their ships even when the sky was overcast and they could not use the positions of the moon, stars, and planets for navigation. By the late 1400's, the advances in ship construction and navigation aids helped make long ocean voyages possible.

The age of overseas expansion. During the 1400's and 1500's, explorers such as Christopher Columbus, Ferdinand Magellan, Sir Francis Drake, and Cheng Ho made great ocean voyages. European voyagers reached India, North and South America, and later Australia and New Zealand. However, this expansion of European culture took several hundred years. In spite of the improvements in ship construction, ocean travel remained extremely slow.

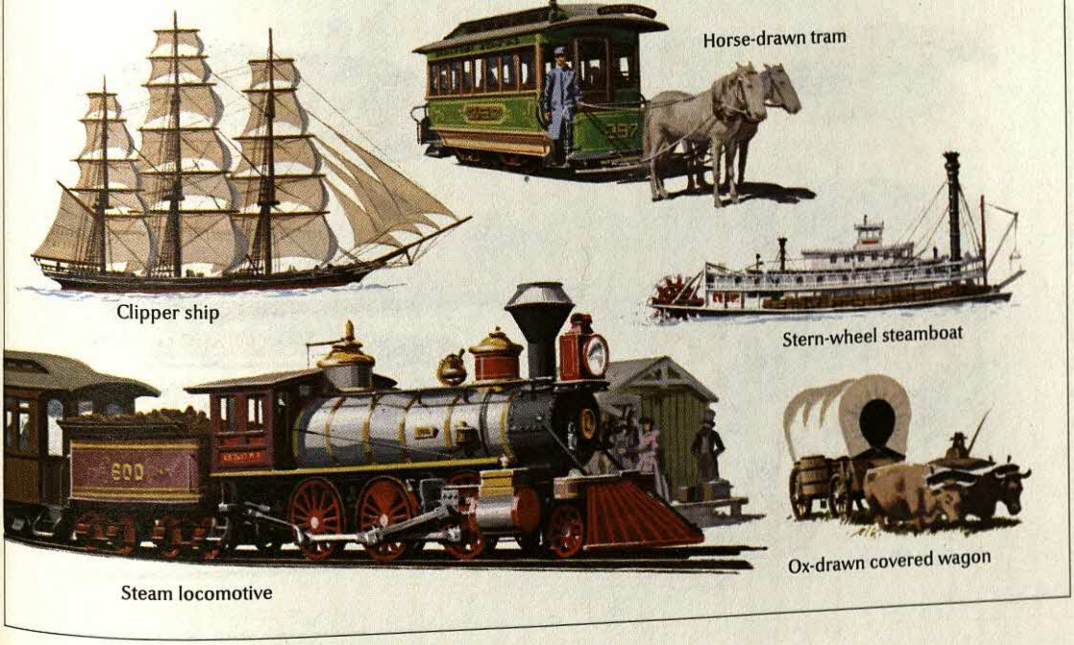
Overseas trade began to increase rapidly during the 1600's. Shipbuilders launched bigger and bigger cargo vessels to handle the growing trade. The bigger ships had to have more sails, and the added sails helped increase speeds. By the mid-1800's, the fastest merchant ships had as many as 35 sails and travelled at speeds of up to 20 knots. These *clipper ships* could sail from New York City, on the eastern side of the United States, around South America, to San Francisco, on the west coast, in three to four months. The overland journey took twice as long.

Development of inland transport. By the 1600's, most people used horse-drawn wagons to haul goods locally. But they seldom used wagons for long hauls because of the poor condition of the roads. Until the mid-1800's, horse-drawn boats and barges were the chief means of long-distance inland transport. The animals trudged along the banks of rivers and canals and pulled the vessels with ropes.

Hundreds of canals were built in Europe from the late Middle Ages to the early 1800's. In 1742, a canal was built in Ireland to link Lough Neagh with the sea at Newry. The first canals in Britain were built to carry coal cheaply from mines to industrial towns. In 1761, the Bridgewater Canal was opened. It linked mines at Worsley with factories in Manchester. The Industrial Revolution could not have succeeded without canals, which carried heavy raw materials and finished goods. By the 1840's, the spread of railways had caused canal traffic to decline. The railways carried goods faster, and over a greater network of routes.

During the 1700's, France and England constructed the first well-built paved roads since Roman times. By the mid-1800's, the first major United States highway, the National Road, had been completed. The highway connected Cumberland, Maryland, and Vandalia, Illinois. It was a gravel road and inferior to the best French and English roads of the time. American pioneers travelling west from the Mississippi River crossed a wilderness without roads. They drove their covered wagons along

Transportation in the 1800's The steam engine provided a completely new source of power for transportation during the 1800's. It was used to propel locomotives and paddlewheel boats and ships. However, people also continued to use older sources of power, such as animals and the wind.



dirt tracks, such as the Santa Fe Trail and the Oregon Trail.

The basic design of wagons and coaches changed little from the late Middle Ages to the 1800's. The first city coach line started in Paris during the 1660's. It was the ancestor of today's commuter services. The first long intercity coach line began service between England and Scotland in about 1670. The line operated between the cities of London and Edinburgh, a distance of about 630 kilometres. The coaches were called *stagecoaches* because they travelled in stages, stopping at scheduled places on a route for changes of horses.

The steam age. The invention of the steam engine marked the beginning of the greatest revolution in transportation since the invention of the wheel and the sailing boat. British inventors developed the steam engine during the 1700's. The first self-propelled road vehicles were powered by steam engines. A French army captain called Nicolas Cugnot built the first such vehicle in 1769. His three-wheeled steam tractor was used to pull cannon. Passenger-carrying steam cars were developed in England and were first used in the early 1800's. In 1807, the first commercially successful steamboat service began in the United States. The first successful steam railway began service in England in 1825. By the late 1800's, ships powered by steam engines had for the most part replaced sailing ships on the world's shipping lanes. However, steam-powered trains played the leading role in the transportation revolution.

By the late 1800's, steam railway locomotives travelled at speeds never imagined possible—up to about 100 kph and faster. They could haul loads hundreds of times heavier than a team of horses could pull. By 1900, railway lines had been built throughout Europe and North America and in many parts of Africa, Asia, Australia, and South America.

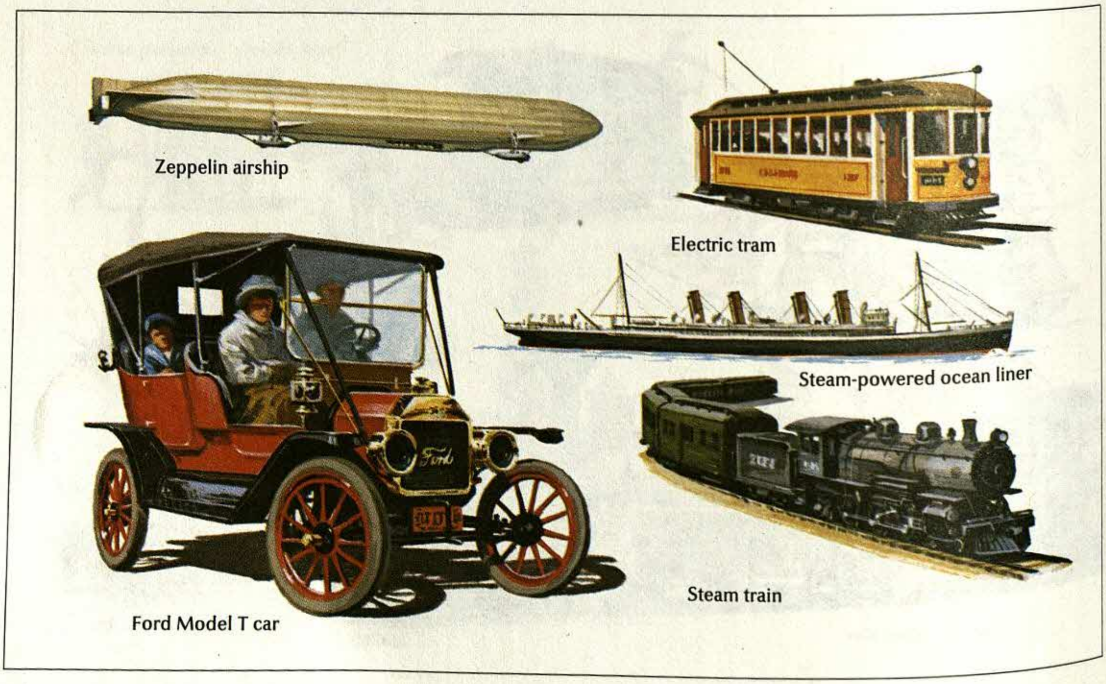
As more and more steamships and steam-powered trains went into service, passenger fares and freight rates dropped. The lower costs encouraged travel, trade, and the growth of cities. In addition, many people became accustomed to fast movement and rapid change. The quickening pace of life created a demand for still faster transportation.

The beginnings of modern transportation. The first electric trains and trams appeared in Europe and the United States during the 1880's. In the 1890's, the German engineer Rudolf Diesel invented the engine that was later named after him. In time, diesel engines replaced steam engines on many ships and on most trains. But of all the inventions of the 1800's, the petrol engine was the one that brought about the most far-reaching changes in transportation.

The bicycle was developed in Europe during the 1800's. In the 1880's, German inventors perfected the petrol engine, and fitted engines to bicycles and tricycles. During the 1890's, French engineers built the first petrol-engined vehicles with car bodies. The first petrol-powered buses and trucks were built in Germany during the 1890's.

In 1903, two American bicycle makers, Orville and Wilbur Wright, used a petrol engine to power a small aeroplane, which they had designed. The Wright broth-

Vehicles of the early 1900's By the early 1900's, engine-powered vehicles had revolutionized transportation. Oceangoing steamships, giant airships, electric trams, powerful steam trains, and the first mass-produced cars were carrying people farther and faster than they had ever travelled before.



ers' machine became the first aeroplane to lift a person into the air and fly successfully.

Motorcars increasingly became an important means of passenger transportation in many industrialized countries during the 1920's. As the number of car owners increased, so did the demand for more and better roads. Many new roads were built in the period between 1900 and 1930.

The first commercial airlines began service in Europe in 1919. Airlines began operations in many other parts of the world during the 1920's. By the late 1930's, the world's airlines carried 3½ million passengers annually. All aeroplanes had propellers and petrol engines. During the late 1930's, German engineers built the first planes with jet engines. All the early jet aircraft were warplanes. The first jet airliners began service during the 1950's.

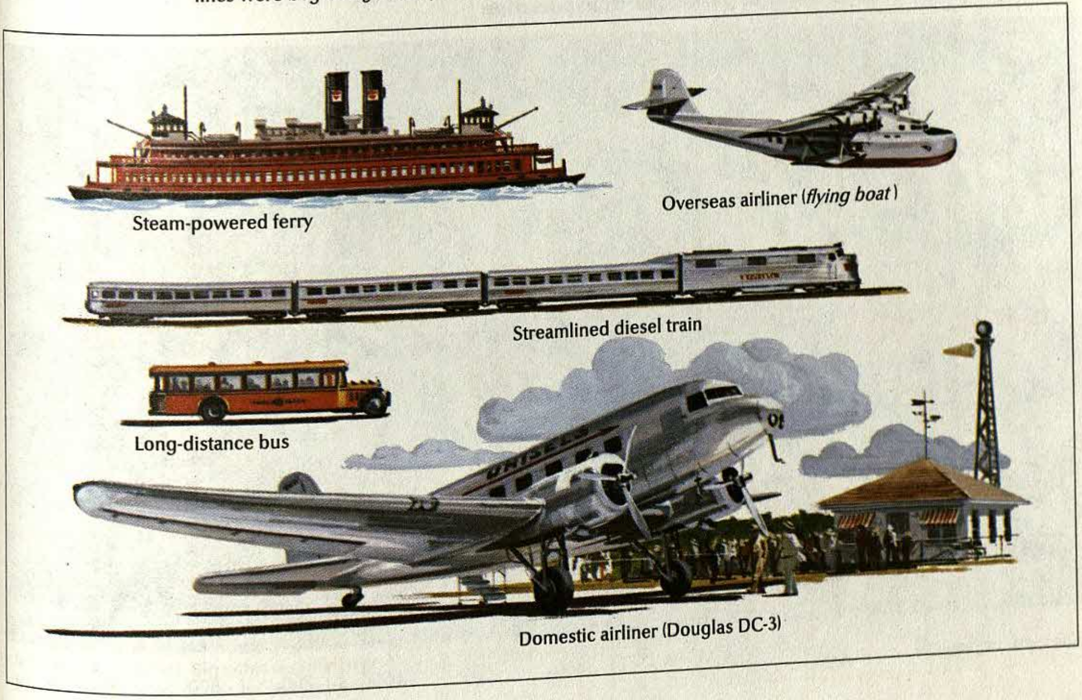
The great advances in transportation during the 1900's have brought about enormous changes in people's lives. The development of commercial air travel has made long journeys routine. As a result of improvements in ocean shipping and in refrigeration, goods that were once available only in certain regions are now distributed worldwide.

The development of the motorcar has led to the growth of sprawling suburbs around big cities. Many people depend on cars for shopping and other personal business. They may also use their cars to get to and from work in the cities. Without this means of private transportation, suburban living would be impractical or impossible for many people.

Important dates in transportation

c.5000 B.C.	People began to use donkeys and oxen as pack animals.
c.3500 B.C.	The Mesopotamians built the first wheeled vehicles.
c.3200 B.C.	The Egyptians made the first sailing craft.
300's B.C.-A.D. 200's	The Romans built the first extensive system of paved roads.
c.800	The rigid horse collar appeared in Europe.
1100's	Wagon makers in Europe built the first horse-drawn carriages. Carriages with spring suspension systems became known as *coaches* during the 1400's.
1490's	Improvements in ship construction helped make long ocean voyages possible.
1660's	The first city coach line opened in Paris.
1700's	British inventors developed the steam engine.
1807	The first commercially successful steamboat service began in the United States.
1825	The first successful steam railway opened in England.
1880's	German inventors built petrol engines and used them to power wheeled vehicles.
1890's	French engineers built the first petrol-engined vehicles with car bodies.
1903	An aeroplane built by Orville and Wilbur Wright of the United States became the first one to lift a person into the air and fly successfully.
1920's-1950's	Cars increasingly became the chief means of passenger transportation in many countries.
1950's	The first commercial jet airliners began service.
1970's	Declining petroleum reserves throughout the world led to shortages of transportation fuel.
1976	The first supersonic passenger airliner, the Concorde, began service between Europe and the United States.
1994	The Channel Tunnel, a rail link joining France and the United Kingdom, was opened.

Transportation in the 1930's Most of today's forms of public transportation had taken shape by the 1930's. Railways were the chief form of intercity public transportation at the time. But bus companies and commercial airlines were beginning to carry more and more passengers. Ferries carried many passengers locally.



Steam-powered ferry

Overseas airliner (*flying boat*)

Streamlined diesel train

Long-distance bus

Domestic airliner (Douglas DC-3)

Transportation today

Before the development of engine-powered vehicles, nearly all transportation involved the shipment of goods. Passenger transportation was relatively uncommon. The development of engine-powered transportation changed this situation dramatically. Today, passenger transportation is an essential part of everyday life in industrialized countries. Workers in these countries live much farther from their places of employment than workers did in the past. As a result, they need quick, dependable transportation each working day. Many children need transportation to and from school. Families depend on transportation for shopping and other errands. Many people travel long distances when going on holiday. In some industrialized countries, more money is spent on the various means of passenger transportation than on the shipment of freight.

This section deals mainly with engine-powered passenger and freight transportation in industrialized countries. In rural areas of developing countries, many people still rely on age-old transportation methods. For a discussion of these methods, see the section *Kinds of transportation.*

Passenger transportation

There are two main types of passenger transportation: (1) private transportation and (2) public transportation. People who use private transportation operate their own vehicles. Those who use public transportation pay to ride on vehicles owned and operated by private companies or the government.

Private transportation in industrialized countries is provided mainly by cars, bicycles, motorcycles, and private aeroplanes. Cars are by far the most important means of private transportation.

For example, most people in the United States travel chiefly by car. Americans use their cars largely for local transportation. But cars are also the leading means of travel between U.S. cities.

Cars are also the chief means of passenger transportation in Australia, Canada, Japan, New Zealand, and most of the nations of Western Europe. People in these countries and in the United States own about 77 per cent of the world's cars. Americans own by far the largest share—about 35 per cent of the world total. The countries with the most cars also have the best road systems. There are about 19 million kilometres of roads throughout the world. About one-third of this length is in the United States. Most of the rest is in the other countries that have a large number of cars.

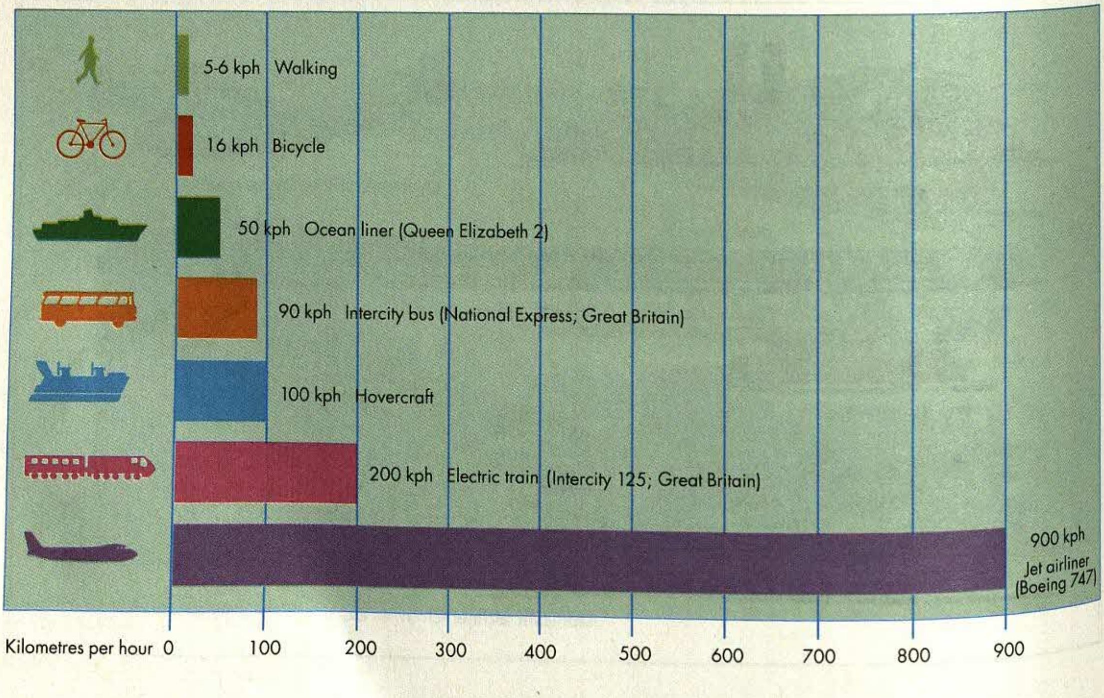
Car travel is far less important in developing countries than in industrialized ones. But a growing number of city dwellers in these developing countries own a car. The biggest cities have had to build more roads to handle the ever-increasing flow of car traffic.

Public transportation. Any organized passenger service that is available to the general public can be classed as public transportation. There are three main types of public transportation service: (1) urban, (2) intercity, and (3) overseas.

Urban service. Most large urban areas provide some means of public transportation for people who do not own a car or who prefer to avoid city driving whenever possible. Public transportation services between cities and their suburbs are sometimes called *commuter services.*

Buses are the principal means of public transportation in most of the world's cities. In addition, many large cities have a railway network, and about 90 cities have

Average speeds of some kinds of passenger transportation



both an above-ground railway network and an underground railway system. Some large cities also have elevated trains, which run on tracks above the streets. In addition, a growing number of large cities have a public transportation system that includes *light rail vehicles.*

A light rail vehicle is an electrically powered railway carriage that gets its power from an overhead trolley wire or an electrified third rail. Trams, or streetcars, are a type of light rail vehicle. During the late 1800's and early 1900's, trams were an important part of the public transportation system in many cities. But most tram tracks ran down the middle of the road, and increasing car traffic began to interfere with the operation of the trams. For this reason, trams have been replaced by buses in many cities.

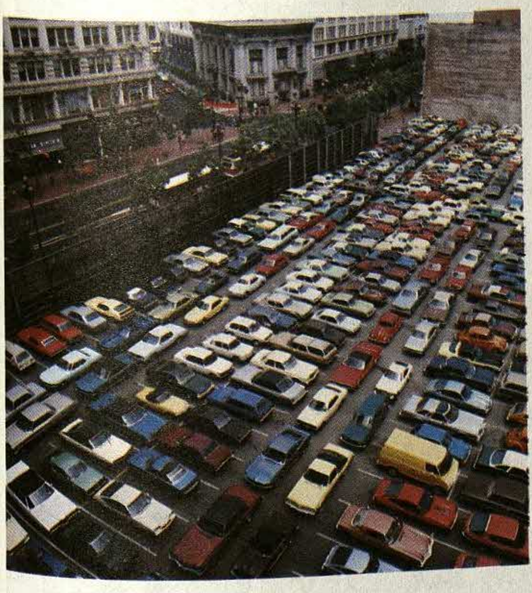
Today's light rail vehicles can run underground, on elevated tracks, or on tracks built alongside city streets. Some of them are operated from computerized control centres instead of by drivers. The cars can travel individually, or they may be linked together to form a train. Many light rail vehicles have rubber-tyred wheels, which help them run more smoothly and quietly than other trains.

Trains are the chief means of public commuter transportation. Many railway networks run commuter trains between big cities and their suburbs.

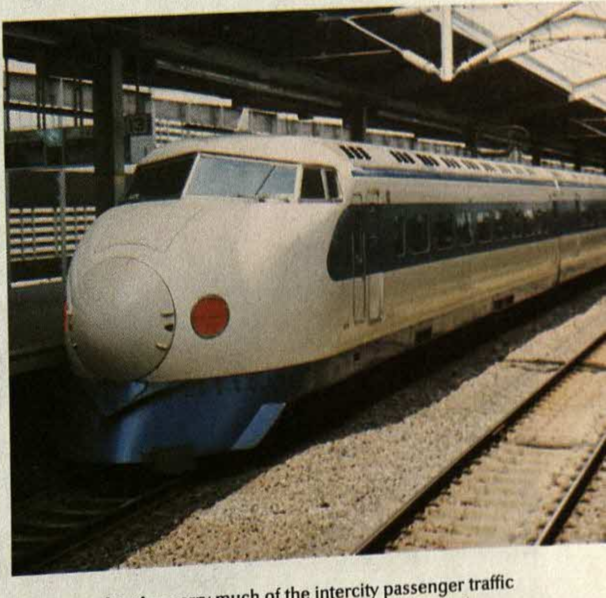
Intercity service is provided mainly by aeroplanes, buses, and trains. Riverboats and ferryboats carry an extremely small share of intercity passengers.

In some industrialized countries, such as Australia and the United States, airlines handle a large proportion of intercity passengers on long trips. However, private cars, buses, and trains are the preferred means of transportation for many people, particularly for short trips. In China, India, and most of Africa, railways and buses

Bicycles are an important form of private transportation in various countries, including the Netherlands, *above.* Many people in Europe, Africa, and Asia ride bicycles to and from work.



Cars are by far the chief means of private transportation in industrialized countries. Big cities require large car parks for the great number of cars driven by workers each day.



High-speed trains carry much of the intercity passenger traffic in Japan and western Europe. The sleek, bullet-shaped train above is part of a large fleet of Japanese express trains.

carry more passengers than private cars and aeroplanes. Railways and buses are the chief modern means of intercity travel in most developing nations. Japan and many Western European countries have high-speed passenger trains. Short-range airliners also play an important part in intercity transport in Europe.

High-speed trains can compete with airliners for passengers on journeys of up to about 800 kilometres. Most big airports are on the outskirts of large cities. For short and medium-length flights, the trip to and from the airport may take longer than the flight itself. Trains, on the other hand, take passengers all the way into stations in city centres. Passengers on a high-speed train may thus complete their entire journey in less time than it would take by air.

Overseas service. The first overseas airlines began operations during the 1930's. But the planes had to stop frequently during a flight for refuelling. Most overseas travellers continued to go by ship until the late 1950's, even though it took far longer to sail than to fly. The voyage across the Atlantic Ocean, for example, took four days or more. The first nonstop transoceanic airliners appeared during the late 1940's. These propeller-driven planes could carry passengers across the Atlantic safely and comfortably in hours rather than days. As these planes became more common, overseas travel increased. The first transoceanic jet airliners began service during the 1950's, leading to a tremendous increase in overseas air travel.

Today, almost all overseas travellers go by plane. Only one ocean liner, the United Kingdom's *Queen Elizabeth 2,* still makes transatlantic voyages. Most ocean liners today operate as cruise ships. They specialize in taking tourists to the Caribbean, the Mediterranean, and other warm areas, stopping at many ports on the way.

In 1976, the first supersonic airliner, Concorde, began service between Europe and the United States. Concorde crosses the Atlantic between London or Paris and New York—about 5,630 kilometres—in 3½ to 4 hours. However, travelling by supersonic airliner is expensive, because these planes consume large amounts of fuel.

Freight transportation

Pipelines provide the cheapest means of transporting petroleum and natural gas. The cheapest way to move general cargo is by water. Rail transportation costs about 3 times as much as water transportation, and truck transportation costs about 10 times as much. Air transportation is by far the most expensive way to move freight. It costs nearly 40 times as much as water transportation. Because air transportation is so costly, cargo planes usually carry only expensive, lightweight, or perishable merchandise.

The various means of moving cargo are used for both (1) domestic freight and (2) international freight.

Domestic freight. Most domestic freight traffic involves the transport of cargo between cities within a country. The cargo is carried by aeroplanes, barges, pipelines, railways, ships, and trucks. Freight shipments within cities consist mainly of pickups and deliveries. Trucks carry nearly all such local freight.

Rail freight is an efficient way of moving heavy materials, such as coal. Freight trains carry bulk loads of ore and similar materials between ports and factories; coal from mines to power stations; oil products from refineries to bulk-distribution depots; and general goods of all kinds. Through freight services operate throughout Europe, with much of the goods carried in *freightliner container trains.*

In many cases, a particular freight shipment must be switched from one type of carrier to one or more other types to reach its destination. For example, many ship-

Concorde, the first supersonic airliner, began service in 1976. Since the 1950's there has been a large increase in overseas air travel. Today, almost all overseas travellers go by plane.

ments travel by train, barge, and truck on their way to the buyer. The movement of freight by more than one method is called *intermodal transport.*

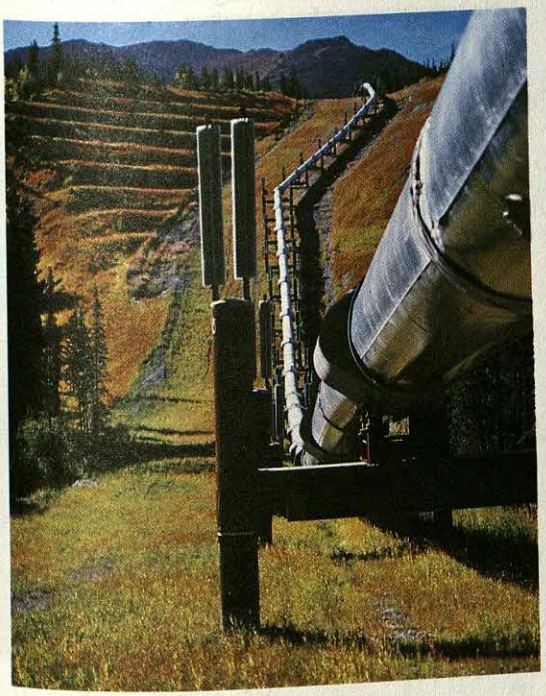
A type of intermodal transport known as *containerization* has become increasingly common since the mid-1900's. Freight is packed into big crates called *containers.* The containers are designed to be carried on truck trailers and railway wagons. They can easily be transferred between the two types of carriers and loaded onto specially designed *container ships.* Containerization reduces shipping costs, speeds deliveries, and cuts losses resulting from breakage. Some domestic freight is containerized. But the method is used mainly in international trade.

International freight is transported mainly by ships. Many of today's merchant ships are designed to carry containers or a particular kind of cargo, such as petroleum, grain, or iron ore. In numerous cases, the ships require specialized port facilities. Most large ports have been equipped to handle containers. Giant cranes and other lifting devices transfer the containers between container ships and truck trailers or railway wagons. Some of the world's busiest seaports specialize in handling oil tanker traffic. These ports have exceptionally deep harbours to accommodate giant tankers. They also have pumping systems and pipelines for loading and unloading the oil.

Some international freight moves by road, rail, pipeline, inland waterway, or aeroplane. European and African countries, especially, depend on these methods in their trade with one another.

Barge transportation is one of the cheapest ways to haul such cargo as coal, grain, and gravel. These barges are being pushed by a tugboat. Some barges, however, have built-in engines.

Intermodal transport is the movement of freight by more than one method. For example, containers loaded with freight may be transferred from truck trailers to railway wagons, *above.*



The Trans-Alaska Pipeline, *above,* is part of a vast network of oil pipelines that crisscrosses the United States. Pipeline companies transport gas and other products as well as oil.

Ships carry most of the international freight. Ships often require specialized port facilities. The Port of Rotterdam, *above,* handles more freight than any other port in Europe.

The transportation industry

Transportation is one of the leading industries in the world. Many of the world's biggest industrial firms earn all or much of their income from the sale of equipment or fuel for transportation. The transportation industry employs many millions of people throughout the world.

The transportation industry consists of (1) equipment manufacturers, (2) passenger and freight carriers, and (3) related industries. The equipment manufacturers and passenger and freight carriers are the key organizations. However, the related industries play a vital role in transportation by providing fuel and various services and facilities. The extent of the involvement of governments in transportation differs according to the political and economic systems of different countries.

Equipment manufacturers produce the vehicles on which modern transportation depends. They also supply the equipment needed to operate the vehicles, such as railway tracks and aeroplane communications systems.

Companies that make cars, buses, and trucks are by far the largest producers of transportation equipment. Leading producers of such motor vehicles include Toyota and Nissan of Japan, Volkswagen of Germany, Fiat of Italy, and General Motors Corporation and Ford Motor Company of the United States.

Passenger and freight carriers include airlines, bus companies, pipeline companies, railways, shipping lines, and road haulage firms. In many countries, the central government owns and operates the airlines and railways and some or all of the intercity bus routes. In the United States, private companies own and operate all the airlines and nearly all the railways.

In some countries in Eastern Europe, the central government also owns the intercity buses, pipelines, shipping, and trucks. In most other industrial countries, these services are provided by privately owned firms, which are subject to various forms of government regulation. In nearly every country, all or most of the urban transportation services are controlled by local governments.

Related industries include glass, petroleum, steel, and tyre production; road construction; the selling of new and used cars; and the servicing of vehicles. Petroleum production is the leading transportation-related industry in terms of value. Several of the world's largest manufacturing firms are oil companies.

Government and transportation. Governments are most deeply involved in transportation in countries where all or much of the industry is publicly owned. But even in countries where nearly all transportation companies are privately owned, government plays a major role in the transportation industry. This role consists primarily of (1) providing funds for certain transportation facilities and (2) regulating aspects of transportation.

Government funding. Four kinds of transportation facilities depend almost entirely on public funds. They are (1) air traffic control centres, (2) airports, (3) public roads, and (4) river and harbour facilities.

Urban transportation systems in most countries depend heavily on government financial support. Few of the systems earn enough from passenger fares to pay all their expenses. Governments must provide whatever additional funds are needed to keep the transportation systems in operation.

Government regulation deals chiefly with transportation safety and the business practices of transportation companies. Governments throughout the world have established safety rules for the various methods of transportation.

Current developments

Problems of modern transportation include (1) traffic safety, (2) declining fuel reserves, (3) environmental problems, and (4) inadequate public transportation. These problems are most severe in countries that depend heavily on transportation using private cars.

Traffic safety. Most types of high-speed, engine-powered transportation involve traffic safety problems. But car drivers have an especially poor safety record. In some countries, such as the United States, more people are killed in car accidents every year than in all other transportation accidents combined. Most car accidents could be prevented if every driver obeyed all traffic laws and all the rules for safe driving.

Airlines have one of the best safety records in the field of transportation. But heavy air traffic at major airports has increased the hazards of commercial flying. When many airliners await clearance to land or take off, airport approaches and runways become dangerously overcrowded. In addition, large airports have a growing amount of private aeroplane traffic, which makes traffic control even more difficult.

Railways are generally a safe means of transportation. Collisions and derailments of trains are rare, but may happen on busy lines when signalling equipment fails, or if track is worn or damaged. Railway companies have track replacement programmes, and regularly check signalling equipment.

Declining fuel reserves. Petrol and other fuels made from petroleum supply nearly all the energy for engine-powered transportation. Energy experts warn that the world's supply of inexpensive petroleum is being used up rapidly. At the current rate of use, the supply may be exhausted by the mid-2000's. Industrial countries must ensure that all their major transportation systems have enough fuel to function normally. On the other hand, these nations must also do all they can to conserve

Energy use in intercity passenger transportation

Kind of vehicle	Average number of passengers per trip	Km vehicle travels per litre of fuel*	Passenger-km per litre of fuel
Train†	188	0.16	29.5
Bus	20	2.5	50.0
Car	2.2	11.1	24.5
Jet airliner	89	0.14	11.9

*A passenger-km is one passenger carried one kilometre.
†Includes trains with diesel or electric engines.
Figures are for 1988. Source: Center for Transportation Research, Argonne National Laboratory, U.S.A.

fuel. Fuel conservation is necessary not only because of the threat of a serious fuel shortage but also because of the high price of petroleum. Higher petroleum prices result in higher transportation costs, and higher transportation costs drive up the prices of transported goods.

Cars consume about half the energy used for transportation in an industrialized country. They therefore contribute heavily to the nation's energy supply problems. To help reduce fuel consumption, governments set fuel consumption standards for new cars. These standards encourage carmakers to produce smaller, lighter cars, which travel farther per litre of petrol than larger models.

Environmental problems. Cars are the chief cause of traffic congestion in urban areas, and their exhaust fumes contribute heavily to urban air pollution. Many cities plagued by traffic jams and air pollution have taken steps to reduce car traffic in their busiest areas. In addition, increasingly strict pollution-control standards are being introduced for new vehicles. These standards require carmakers to manufacture cars that give off cleaner exhausts than earlier models.

Inadequate public transportation. Greater use of public transportation would help ease the problems caused in many countries by the heavy dependence on cars. But public transportation must be improved before more car drivers can be persuaded to use it.

Improvements in public transportation chiefly involve expanding and upgrading (1) urban services and (2) intercity train services.

Improvements in urban services. Most cities today cannot afford to build extensive new urban transportation facilities. But many cities are trying to improve their existing facilities. For example, a number of cities have speeded up bus services by reserving certain traffic lanes for buses only. In addition, parking restrictions have been made tougher in some city centres, to discourage motorists from bringing their cars into the city. Some cities, such as Singapore, allow each driver to use city centre roads only on certain days of the week.

Some experts believe electrically powered light rail systems can help improve urban transportation in many cities. Light rail vehicles have several advantages over other kinds of passenger vehicles. They do not produce exhaust fumes as buses do, and they run more smoothly and quietly than most underground railways. Light rail systems also cost less to build than underground railways. Several cities built light rail systems in the 1970's and 1980's.

Another type of urban transportation is the *people mover.* People movers carry passengers along specially constructed guideways in driverless, electrically powered cars. The cars operate automatically. They move along the guideways and stop at designated points to take on and discharge passengers.

Improvements in intercity train services. Most industrialized countries are trying to improve railway passenger services along heavily used intercity routes. Trains use less energy per passenger than do cars, aeroplanes, and buses. Thus, railways could help conserve energy if they attracted passengers away from air and road travel.

The magnetic levitation (maglev) train is a high-speed passenger vehicle currently being developed. A magnetic force holds the vehicle above a guideway and drives it forward. Maglev trains are expected to travel at more than 480 kilometres per hour.

People movers are vehicles that carry passengers along guideways in driverless, electrically powered cars. The cars operate automatically and stop at designated points.

In western Europe, high-speed passenger trains run on special tracks in France and Germany. The tracks have no sharp curves, which allows the trains to average over 200 kph. A network of high-speed railways is being built to provide fast rail service for passengers and freight between major European cities. The Channel Tunnel, linking France and the United Kingdom beneath the English Channel, opened in 1994. It is a rail link with cars, trucks, and buses travelling through the tunnel on trains.

Australia's fastest trains are the XPT services in New South Wales, which operate at 160 kph on main lines radiating from Sydney.

High-speed electric trains provide swift intercity service in Japan and several European countries, including France, Italy, and the United Kingdom. Japan's "bullet train," which reaches a speed of 210 kph, links cities on the main island of Honshu. The French TGV (*train à grande vitesse,* or high-speed train) connects Paris with cities in western and southern France. It travels at a top speed of 300 kph. Both the bullet train and the TGV have reached higher speeds in test runs.

Engineers are working on a new type of high-speed passenger train called a *magnetic levitation train* or *maglev train.* The track for maglev trains consists of a single guideway, which the vehicle straddles but does not touch when in motion. Magnets on both the guideway and the underside of the train create a powerful magnetic force. This magnetic force lifts the vehicle above the guideway. Magnetic forces also push the train forward. Maglev trains are expected to travel more than 480 kph. But only low-speed maglev trains are in operation today. See **Magnetic levitation train.**

Related articles in ***World Book.*** See the *Transportation* section of the country and continent articles. See also the following articles:

Land transportation

Ambulance
Aqueduct
Bicycle
Bridge
Bus
Car
Carriage
Chariot
Coach
Conveyor belt
Electric railway
Elevated railway
Escalator
Fire brigade (Fire engines)
Jinrikisha
Lift
Magnetic levitation train
Monorail
Motorcycle
Pedicab
Petroleum (Transporting petroleum; diagram)
Pipeline
Railway
Recreational vehicle
Road
Snowmobile
Taxi
Tractor
Tram and trolleybus
Travois
Truck
Tunnel
Underground railway
Viaduct
Wagon

Water transportation

Barge
Canal
Harbour
Hovercraft
Lighthouse
Merchant navy
Port
Raft
Ship
Submarine
Tanker

Air transportation

Aeroplane
Airmail
Airport
Airship
Aviation
Balloon
Helicopter

Beasts of burden

Camel
Carabao
Donkey
Dromedary
Elephant
Horse
Llama
Mule
Ox
Reindeer
Water buffalo
Yak

Other related articles

Common carrier
Communication
Containerization
Exploration
Industrial Revolution
Navigation
Rocket
Space exploration

Outline

I. Kinds of transportation
  A. Land transportation
  B. Water transportation
  C. Air transportation
II. History
III. Transportation today
  A. Passenger transportation
  B. Freight transportation
IV. The transportation industry
  A. Equipment manufacturers
  B. Passenger and freight carriers
  C. Related industries
  D. Government and transportation
V. Current developments
  A. Problems of modern transportation
  B. Improvements in public transportation

Questions

In what countries are cars the chief means of passenger transportation?
Why is engine-powered transportation expensive?
What caused a great increase in overseas air travel from the 1950's?
Who were the first people to build an extensive system of paved roads?
What are the chief urban transportation vehicles?
What vehicles are moved by muscle power?
What are the chief advantages of using containerized freight shipment?
Why is the shipment of goods by air limited to expensive, lightweight, or perishable cargo?
Why are most industrial countries trying to improve their intercity passenger train services?
What two inventions of late prehistoric times revolutionized transportation during the following centuries?

Transportation was the system of exiling criminals from Britain (now known as the United Kingdom) to the British colonies, particularly to Australia. Between the 1730's and 1776, the British government sent criminals to the cotton fields of America. But after the loss of the American colonies, British jails became overcrowded. The government accepted the advice of Sir Joseph Banks, who recommended the establishment of a penal settlement at Botany Bay, Australia.

The First Fleet, carrying about 750 convicts, sailed from Portsmouth, England, on May 13, 1787. It entered Botany Bay on Jan. 18, 1788. In June 1790, the Second Fleet arrived with 1,000 more convicts. About 250 convicts had died during the voyage. In 1791, the Third Fleet arrived at the settlement. It carried 1,900 more convicts. But another 200 had died on the voyage out. Humanitarians in both Britain and the colony protested. The government tried to improve the conditions in the fleets that followed. But conditions did not really improve until after 1815, when naval surgeons were put in charge of the welfare of the convicts.

The government assigned most of the convicts as servants. Their masters provided them with food and clothing, and paid them small wages. If they were unsatisfactory workers, the government took them back and often put them to work in chain gangs. If they committed crimes, they were flogged, hanged, or sent to penal settlements at Norfolk Island in the southern Pacific

Ocean, Moreton Bay in Queensland, Macquarie Harbour or Port Arthur in Tasmania. The conditions for convicts in these places were often crude and harsh. Many tried to escape but often died or were recaptured.

Many convicts gained *tickets of leave*—they were allowed to work or own land, but had to report regularly to the authorities. Others, called *emancipists,* gained pardons or served their terms. The proportion of convicts in the community gradually decreased. In 1810, almost a third of the 12,000 people living in New South Wales were convicts. By 1851, only about 1 in every 10 were convicts.

In 1840, the British government agreed to stop transportation to New South Wales. In 1848, it tried to reintroduce the system, but hostile crowds greeted the convict ships *Hashemy* in Sydney and *Randolph* in Melbourne. Transportation continued to Van Diemen's Land (now Tasmania) until 1852. In 1849, the British government complied with the pleas of the Western Australian colonists for convicts as cheap labour. It sent most convicts there until 1868. Between 1788 and 1868, more than 164,000 convicts landed in eastern Australia, and more than 10,000 in western Australia.

See also **Australia, History of; Convicts in Australia.**

Transsexualism is a condition in which a person experiences persistent discomfort about his or her sexual designation. Such individuals, called *transsexuals,* want to remove their body's sexual characteristics and obtain the characteristics of the opposite sex. Transsexuals feel a strong need to act like and be treated as a member of the opposite sex. Transsexualism occurs more in males than in females.

The cause of transsexualism is unknown. Some behavioural scientists think it results from an early disturbance in the mother-infant relationship and a lack of proper identification with the same-sex parent. There is no evidence of hormonal abnormalities in transsexuals.

Transsexuals sometimes seek *sexual reassignment surgery* to change their external anatomy permanently to that of the opposite sex. Patients should receive careful psychiatric evaluation before the surgery because various psychiatric disorders can lead to unhappiness with one's sex type. In addition, psychotherapy is needed to explore the motivation for the operation.

People considering sexual reassignment surgery are advised to live and dress as a member of the opposite sex for up to two years. By doing so, they can demonstrate their ability to function as members of the opposite sex. During this time, they can take hormones of the opposite sex to obtain secondary sexual characteristics of that sex. For example, a woman taking male hormones will grow facial hair, and a man taking female hormones will develop breasts.

Trans-Siberian Railway was the first railway built across Siberia, the vast area that makes up most of the Asian part of Russia. When completed, it was the longest railway in the world, extending over 8,000 kilometres from Yekaterinburg and Chelyabinsk in the Ural Mountains to Vladivostok, east of China on the Sea of Japan. It was originally called the Great Siberian Railway. No railway today is officially named the Trans-Siberian Railway. Today, a train called the Trans-Siberian Express travels from Moscow to Vladivostok in seven days. It runs from Moscow to Yekaterinburg, where it joins the original Trans-Siberian Railway line. It has been electrified, with minor gaps, between Moscow and Vladivostock. For the route of this railway, follow the rail lines from Moscow to Vladivostock on the **Russia** political map.

Construction of the Trans-Siberian marked the beginning of a new era in the development of Siberia. Industries and trade began to develop, and the population grew. The railway was a valuable asset to the country during a war with Japan in the early 1900's and during World Wars I and II. It was used to transport troops and supplies across a vast territory.

The Trans-Siberian was built in several sections between 1891 and 1916. The section in eastern Siberia, between Vladivostok and Khabarovsk, had been completed in about 1897. From 1892 to 1912, other sections were built across western and central Siberia.

Between 1897 and 1903, Russia built the Chinese Eastern Railway across Manchuria, in northeast China. This railway connected Vladivostok with the sections of the Trans-Siberian in western and central Siberia. By 1904, a continuous railway stretched from Vladivostok across China and Siberia to the Ural Mountains.

The Russians wanted a railway route that did not cross China. They built a line north of China from Khabarovsk to Kuenga. Completed in 1916, it was the last link in a continuous railway on Russian soil between Vladivostok and the Ural Mountains. Another railway led from the Urals west to Moscow. Since the 1920's, the Trans-Siberian has been joined to other railways in the region. See also **Asia** (picture).

Transubstantiation is a doctrine of the Roman Catholic Church. It explains the belief that bread and wine are changed into the body and blood of Jesus Christ during the sacrament of the Eucharist, or Mass. Transubstantiation indicates that Jesus is present in a real way under the appearance of bread and wine.

The word was first adopted by the church at the Fourth Lateran Council in 1215, and reaffirmed by the Council of Trent in 1551. The term had been in widespread use since the 1100's. Some Eastern Orthodox Christians accept transubstantiation as one of several explanations for the transformation of bread and wine. Some Protestant churches have similar doctrines concerning real presence.

See also **Roman Catholic Church** (The Eucharist, or Mass); **Communion; Mass.**

Transuranium element is a radioactive element that has an atomic number higher than 92, the atomic number of uranium. Transuranium elements are also called the *transuranic elements.* The known transuranium elements have atomic numbers from 93 to 109. They are neptunium (Np), plutonium (Pu), americium (Am), curium (Cm), berkelium (Bk), californium (Cf), einsteinium (Es), fermium (Fm), mendelevium (Md), nobelium (No), lawrencium (Lr), and elements 104, 105, 106, 107, 108, and 109. Each element has a separate article in *World Book.*

Scientists produce these elements artificially through a process called the *transmutation of elements* (see **Transmutation of elements**). In general, the known transuranium elements are considered unstable because they undergo *radioactive decay* (loss of atomic particles). They are not found much in nature because they decay rapidly. See also **Radioactivity.**

Transvaal was a province of South Africa from 1910 to 1994. It formed the northern part of the country and included the cities of Pretoria, Johannesburg, Vereeniging, and Pietersburg. The name Transvaal comes from the Latin *trans* (across) and the Vaal River. The province shared borders with Botswana to the west, Zimbabwe to the north, and Mozambique to the east. The homelands of Gazankulu, KaNgwane, KwaNdebele, Lebowa, Venda, and parts of Bophuthatswana lay within the Transvaal (see **South Africa, History of**). In 1994, nine new provinces replaced South Africa's four provinces and ten homelands. Transvaal was absorbed into the new provinces of Pretoria-Witwatersrand-Vereeniging (PWV), Eastern Transvaal, Northern Transvaal, and North West. In 1995, PWV was renamed Gauteng, and Northern Transvaal became Northern Province.

The southern and central parts of the Transvaal formed part of the *highveld,* the interior high-lying plateau of South Africa (see **Veld**). The Great Escarpment in what is now the Eastern Transvaal marks the division between the highveld and lowveld.

The area covered by the former Transvaal province is an important mining, manufacturing, and agricultural region. It contains most of South Africa's mineral wealth, including large deposits of coal, diamonds, and gold. Major farm products include beef, dairy produce, fruit, maize, sunflower oil, tea, tobacco, vegetables, and wheat. Manufacturing in the former Transvaal includes the production of beverages, chemicals, clothing, food, machinery, paper, textiles, iron and steel, and wood.

History

The earliest known inhabitants of the Transvaal were the Khoisan (see **Khoisan**). From about A.D. 300, early Iron Age communities began to settle in the lowveld and bushveld regions (see **Iron Age**). From about 1050, the highveld was occupied by ancestors of the Sotho and Tswana tribes (see **Sotho** and **Tswana**). The arrival of Mzilikazi and his Ndebele followers in the 1820's completely disrupted these communities (see **Mzilikazi**). Ndebele swept across southern and central Transvaal from east to west. Only a section of the Pedi people under Sekwati in eastern Transvaal managed to create a Sotho state strong enough to survive this invasion.

The southern and western Transvaal were under the control of Mzilikazi when the white Afrikaner settlers known as the *voortrekkers* (forerunners) first crossed the Vaal River in 1836 (see **Boers; Great Trek**). Alarmed by this apparent invasion, Mzilikazi attacked them. The voortrekkers beat off the Ndbele at Vegkop and sent an expedition to defeat Mzilikazi in January 1837. This force drove him northward toward Zimbabwe.

Some of the voortrekkers, led by A. H. Potgieter, established settlements at Potchefstroom in the west, Andries-Ohrigstad in the east (1845), and Schoemansdal in the north (1848). More trekkers came to the Transvaal from Natal after its annexation in 1842. Their leader, Andries Pretorius, negotiated the Sand River Convention in 1852, under which the United Kingdom (UK) recognized the Transvaal as an independent Boer republic.

In 1855, the government of the Transvaal founded Pretoria as the capital, named after Andries Pretorius. The new republic adopted a constitution in 1858. Marthinus Pretorius, son of Andries, was the first president.

Oranges grown in the former Transvaal provide about half of South Africa's total crop.

Hoping to create a South African federation, the British annexed the Transvaal in 1877. They defeated both the Pedi and the Zulu who threatened the Transvaal. The Boers fought against the annexation in December 1880. After their defeat at Majuba in January 1881, the British agreed to the Pretoria Convention, which gave back independence to the Boers. The new state was called the Zuid Afrikaansche Republiek (ZAR).

The discovery of gold on the Witwatersrand in 1886 started a gold rush. As a result, the British once again tried to gain control of the ZAR. In 1895, Cecil Rhodes, the prime minister of the Cape Colony, plotted to overthrow the Transvaal government. He sent a force under Leander Jameson to invade the country. But the Boers captured the invaders, and the so-called Jameson Raid failed. Relations between the UK and the Transvaal then grew more strained. The British government forced the ZAR into declaring war in October 1899.

The British swept into the Transvaal in May 1900. President Paul Kruger fled, but many of the Boers fought a guerrilla war against the British until May 1902.

By the Treaty of Vereeniging (1902), the Transvaal became a British colony. The United Kingdom gave colonial self-government to the province in 1906. This act led to the establishment of the Union of South Africa in 1910. The Transvaal capital, Pretoria, became the executive capital of the union.

In March 1994, parts of the Bophuthatswana homeland that lay within the Transvaal were the scene of an important conflict. Bophuthatswana's president, Lucas Mangope, had tried to prevent his homeland from becoming part of the new, unified South African state created on April 27, 1994, the date of South Africa's first democratic general election. Homeland citizens staged strikes and riots in protest against Mangope's policies. In response, the president invited the extreme right-wing Afrikaner Volksfront into the homeland from the Transvaal to help restore law and order. However, the Bophuthatswana Defence Force quickly defeated the armed extremists and Mangope was deposed.

Related articles in ***World Book*** include:

Anglo-Boer Wars
Eastern Transvaal
Gauteng
Johannesburg
Mzilikazi
North West
Northern Province
Pretoria
South Africa
Vaal
Vereeniging

Transverse arch. See **Foot** (The arches).

Transylvania is a geographical region of Romania near the Hungarian border. It covers about 100,000 square kilometres. The majority of its 7½ million people are Romanians. But about 1½ million Magyars also live there. Magyars make up the largest ethnic group in Hungary. The Carpathian Mountains and Transylvanian Alps separate the region from the rest of Romania. See **Romania** (map).

Transylvania has rich deposits of iron, lead, lignite, manganese, natural gas, and sulphur. The surrounding mountains are covered with beech and oak trees. Transylvania's high plains make good grazing grounds for cattle and sheep. Its valleys produce large bean, maize, potato, tobacco, rice, and wheat crops. The region's largest city is Cluj-Napoca.

For years, Romanians and Hungarians quarrelled over Transylvania. Magyars conquered the region in the 900's. From 1526 to 1699, Transylvania was part of the Ottoman (Turkish) Empire. It was under Hungarian control from 1699 to 1867, when it once again became part of Hungary. During World War I (1914-1918), Romania joined the Allies after being promised Transylvania. After the war, Transylvania became part of Romania. In August 1940, Germany and Italy forced Romania to give northern Transylvania to Hungary. After World War II (1939-1945), Transylvania was returned to Romania, and lost its political identity.

Transylvania is the main site of the legend about the famous vampire Dracula. The character of Dracula is based on Vlad Tepes, a cruel prince of the 1400's who lived in Walachia, a region south of Transylvania. Vlad executed many of his enemies by driving a sharpened pole through their bodies. A belief in vampires formerly held by many Romanian peasants added details to the legend. *Dracula* (1897), a novel by the English author Bram Stoker, made the legend internationally famous. This immensely popular book has inspired numerous plays and films.

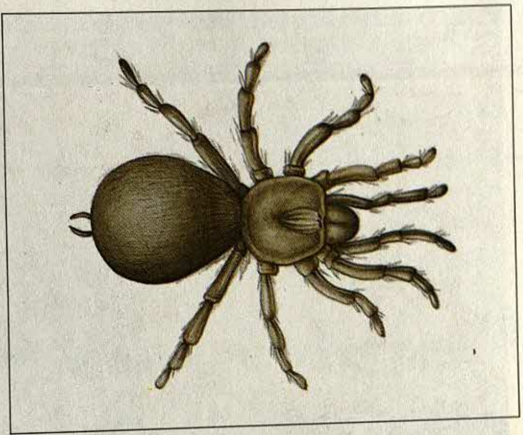
See also **Dracula; Romania** (Land regions).

Trap-door spider digs a burrow in the ground and covers the entrance with a lid, or trap door. It lives in warm climates all over the world. It is harmless to human beings. Some trap-door spiders grow to over 2.5 centimetres long. These spiders are a type of *tarantula* (see **Tarantula**).

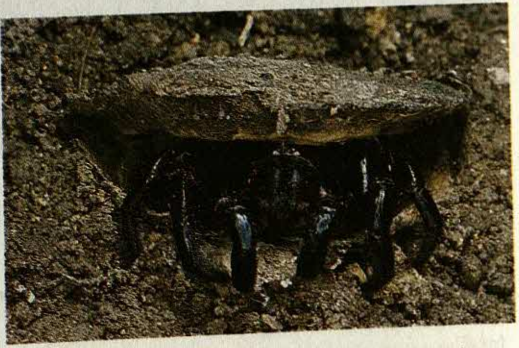
Trap-door spiders use their burrows for protection and as nests in which to raise young. The burrows are lined with silk. Some burrows are more than 25 centimetres deep and over 2.5 centimetres wide. Some trap-door spiders dig simple, tubelike burrows. Others dig burrows that have a branch tunnel. The branch tunnel, sometimes hidden by a second trap door, serves as an extra hiding place.

The trap doors are made of silk and mud, and are attached to the lining of the burrows by silk hinges. Some trap-door spiders build thin, waferlike doors that cover the burrow entrance loosely. Others construct thick doors, like corks, that fit so snugly into the tunnel entrance they are watertight. Still others build circular folding doors that open in the middle.

Trap-door spiders eat insects, including many kinds that damage valuable plants and flowers. The spider waits behind its door until its prey walks by. Then it quickly opens the door, seizes and poisons its victim, and drags it into the burrow. Trap-door spiders are timid, and the females seldom leave their nests. They are preyed upon by scorpions, which will enter the spiders' burrows to eat them.



The trap-door spider is harmless to human beings.

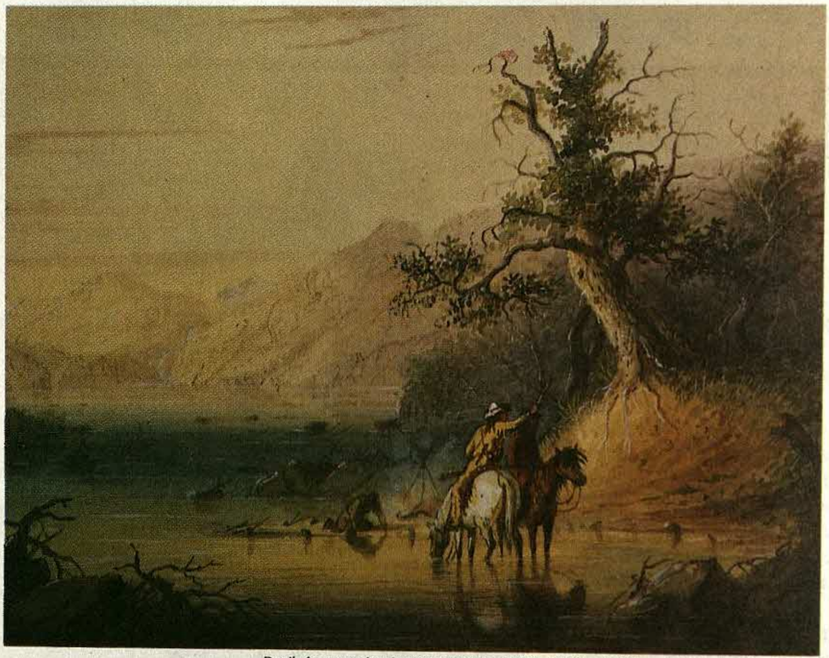


The trap-door spider's home is a silk-lined burrow. At the top is a hinged door made of silk and mud. The spider uses the burrow for protection and as a nest for its young.

A female trap-door spider's abdomen, *left,* contains many eggs. The eggs are placed in the burrow to hatch.

Scientific classification. Trap-door spiders make up the trap-door spider family, Ctenizidae.

Trapezoid. See **Quadrilateral.**



Detail of a watercolour (1858) by Alfred Jacob Miller; Walters Art Gallery, Baltimore, Maryland, U.S.A.

Beaver trapping was a profitable occupation for many pioneers during the 1700's and 1800's in North America. They used steel traps held in place by a chain and stake. The trappers sold the pelts or traded them for food and other supplies. Most beaver pelts were made into hats and sold in Europe.

Trapper. See Trapping.

Trapping is the capture or killing of wild animals in traps. It was one of the first methods by which people obtained animals for food and clothing, and in many parts of the world people still trap for food. Some African tribes, for example, trap antelope and monkeys for food.

People also trap for profit. In North America, many pioneers of the 1700's and 1800's became wealthy by trapping fur-bearing animals. They sold the pelts for use in making fashionable fur garments. Today, much of the fur supply comes from the manufacture of artificial furs and from farms that raise fur-bearing animals such as mink and chinchilla. But many people still trap for sport and profit. Animals that are trapped for their fur include bears, beavers, foxes, martens, minks, muskrats, and raccoons.

People also trap for other reasons. For example, scientists trap wild animals unharmed to study their habits. Farmers and ranchers use traps to catch such animals as foxes and wolves, which kill chickens and sheep. Animals that prey on other animals are called *predators.* Many homeowners trap mice, moles, and other pests that ruin lawns or invade cupboards looking for food.

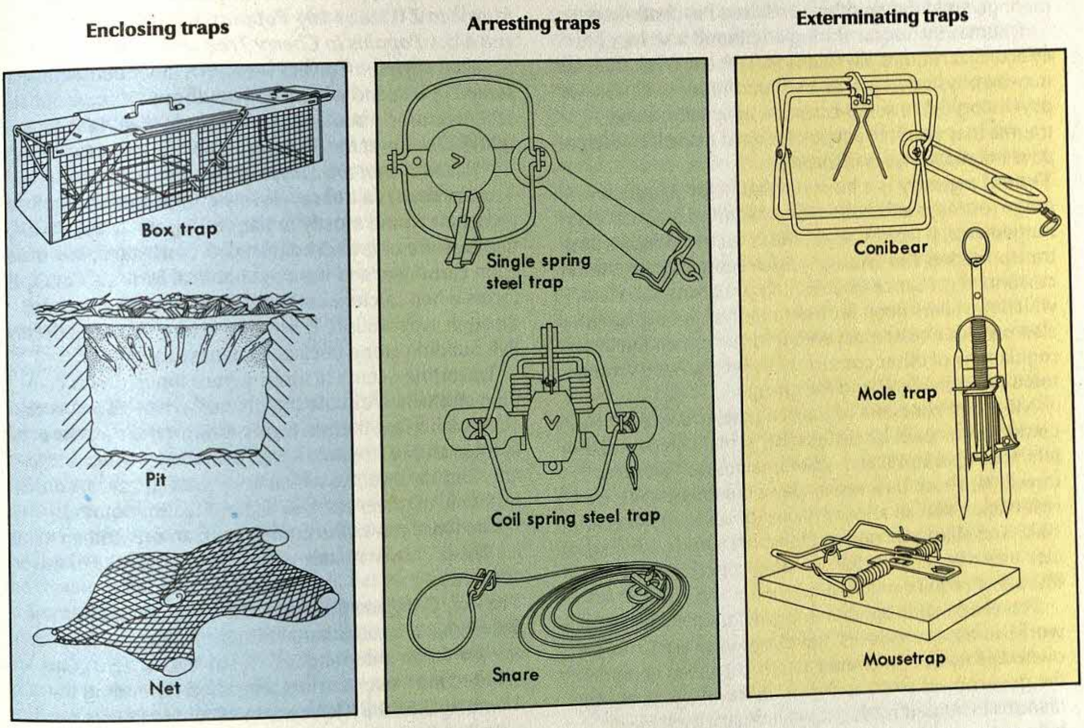
Kinds of traps. There are three main types of traps: (1) arresting traps, (2) enclosing traps, and (3) exterminating traps. Bait can be used in any trap, but it may not be necessary.

Arresting traps grip animals but do not kill them. The most common arresting trap is the *steel trap.* Manufacturers make steel traps of various sizes and shapes to catch such animals as foxes and raccoons. Steel traps have jaws that operate with a steel spring and grip an animal by the foot or leg. Some have teeth that can hurt an animal badly if it struggles to get free. Great Britain considers steel traps inhumane and bans them. Some states of the United States forbid steel traps with teeth.

Enclosing traps hold animals unharmed. A common type is the *box* or *cage* trap. The trapper uses bait to lure an animal into a box trap, and a door then closes and imprisons it. Animal collectors and scientists often use box traps to catch animals for zoos or research. Scientists may trap an animal and tag it so they can follow the creature's movements after freeing it from the trap.

An enclosing trap captures animals alive. These members of the U.S. Bureau of Wildlife Management have trapped a black bear. They will examine and tag the animal before releasing it.

Kinds of traps The type of trap a person uses depends on the kind of animal being trapped and on whether the animal is to be unharmed or killed. Bait can be used in any trap, but it may not be necessary. For example, trapping minks and muskrats seldom requires bait. The trapper simply conceals the traps in areas where the animals live and waits for them to trap themselves.



Many people use box traps to catch squirrels or other animals in their gardens or homes. They then release the animals in an unpopulated area.

Exterminating traps grip animals and kill them. They include the *mousetrap* used in many homes and barns. A common mousetrap has metal rods that snap shut by means of a coiled spring and break the victim's neck. Another exterminating trap, widely used in the United States for catching beavers and muskrats, is the *Conibear*. Its metal rods clutch the animal in a "scissors" grip and crush it to death instantly.

Trapping and wildlife conservation. Wildlife conservation groups often criticize any trapping that involves killing animals. They fear that certain animals may become extinct if people continue to hunt them.

Some people believe that trapping predators upsets the balance of nature (see **Balance of nature**). They feel that killing predators will in time result in an oversupply of rodents and other animals that predators eat. But others point out that when some animal species become too numerous, the population of predators increases because the predators have a larger food supply.

Some countries have tried to preserve wildlife with various laws, including total bans on the trapping of certain animals. Trapping laws vary from country to country. Each country issues trapping licences and determines where and when animals may be trapped. They also decide what species may be trapped and what number of animals may be trapped at one time. In Great Britain, for example, no wild animal may be trapped except under special circumstances. These include the prevention of serious damage to livestock or crops, fruit, timber or any other form of property, or to fisheries. The traps that may be used are specified in detail, and they can be used only for taking or killing mice, rats, grey squirrels, stoats, weasels, or other small ground vermin. They can be used only in specified places.

Some countries prohibit the importation of any endangered species or of products made from any such species. Supporters of such laws believe that fewer of these animals will be trapped and hunted in other countries if there is no market for them abroad. Special permits may be issued to exclude animals to be used for research.

See also **Fur**.

Trappists are Roman Catholic monks who belong to the Order of Cistercians of the Strict Observance. This branch of the Cistercians dates from a reform begun in 1664 at La Trappe Abbey in Normandy, France, by the abbot Armand-Jean le Bouthillier de Rancé. He restored rules of the original Cistercian abbey that no longer were followed, including almost complete silence, four to six hours of manual labour a day, and seclusion. He added other rules, such as abstaining from meat, except for the infirm. Orders of Cistercian Nuns of the Strict Observance, called Trappistines, were founded in 1794 by the monk Dom Augustin de Lestrange. Their first convent was La Sainte Volonté de Dieu, near Fribourg, in Switzerland. See **Cistercians**.

Trauma, in psychiatry, is an unpleasant emotional experience of such intensity that it leaves a lasting impression on the mind. Psychoanalysts believe that childhood traumatic experiences can sometimes lead to later emotional symptoms. The study of such childhood traumas plays an important part in the psychotherapeutic treatment given to the emotionally ill (see **Psychotherapy**).

Traumas that occur during adulthood also may have effects that require psychiatric treatment. Such traumas may be physical—such as a serious injury or illness—or psychological. In some cases, an unusually severe trauma may result in a type of mental disorder called a *post-traumatic stress disorder.*

Travel agency is a business that helps people arrange journeys and holidays by handling their travel arrangements. It makes reservations for hotel rooms and transportation and arranges sightseeing tours. It offers customers guidance in obtaining passports and visas, which travellers need for foreign travel. A travel agency also provides customers with information on the travel regulations of other countries. Travel agencies arrange tours for individuals and for groups.

Most of the income of travel agencies comes from commissions paid by airlines, car rental companies, hotels, tour operators, and other businesses that serve travellers. These businesses pay a commission on each reservation that an agency makes or on each ticket it sells. Travellers pay nothing for most services. But agencies may charge a fee for planning special individual tours that require much of their time and effort.

Travel agencies operate in most countries of the world. In many countries, travel agencies are privately owned. However, in some Eastern European countries, the government owns and runs all travel agencies. Regulations instituted by the travel industry itself have helped to establish standards of ethical conduct for travel agents.

Traveller's cheque is a cheque that can be used as money or as a letter of credit. Banks and travel agencies issue traveller's cheques. The purpose of traveller's cheques is to protect the money carried by travellers. People sign the cheques when they buy them and again when they spend them.

Marcellus F. Berry, general agent of the American Express Company, originated the system of traveller's cheques in 1891. Traveller's cheque companies make their profits because they receive money for the cheques long before the cheques are paid out.

Most banks and travel agents sell traveller's cheques and charge a small fee for them. People can redeem them in foreign currencies abroad at the rate of exchange when converted. Thus, travellers bear the risk of exchange fluctuation. If travellers plan to be chiefly in one country, such as Great Britain or France, they may buy cheques denominated in pounds sterling or French francs to avoid this risk. Traveller's cheques are accepted throughout the world in hotels, restaurants, shops, or in exchange for currency. Their use diminished in the 1970's and 1980's, because of the increasing use of credit cards, which were widely accepted for payment of goods and services.

See also **Letter of credit**.

Travers, Morris William. See **Krypton; Neon.**

Travers, P. L. (1906-   ), an Australian-born author, became known for her children's stories about Mary Poppins, an English *nanny* (nursemaid) who has magical powers. Travers introduced the character in *Mary Poppins* (1934). She continued the series with *Mary Poppins Comes Back* (1935), *Mary Poppins Opens the Door* (1943), *Mary Poppins in the Park* (1952), *Mary Poppins from A to Z* (1962), *Mary Poppins in the Kitchen* (1975), and *Mary Poppins in Cherry Tree Lane* (1982).

Pamela Lyndon Travers was born in Queensland and settled in England when she was about 17 years old. Her other children's books include *I Go by Sea, I Go by Land* (1941), *The Fox at the Manger* (1962), *Friend Monkey* (1971), and *About the Sleeping Beauty* (1975).

Travertine is a dense, closely compacted form of limestone found mostly in banded layers. Most travertine is white or cream coloured. It consists mainly of calcium carbonate and has the chemical formula $CaCO_3$. It forms when calcium carbonate separates from water through evaporation. Travertine is often used as decorative building stone because it is easy to cut.

Travertine occurs in areas where limestone is common and where circulating ground water contains calcium carbonate. It often forms around the mouths of hot springs and in streams. Rock formations called *stalactites* and *stalagmites,* which are found in caves, consist primarily of travertine (see **Stalactite; Stalagmite**).

The word *travertine* comes from an old Roman name for Tivoli, a town in Italy where large deposits of travertine occur.

Travis, William Barret (1809-1836), was a hero of the Alamo, a famous battle that took place during the war for Texan independence from Mexico. He commanded the Texas patriots who died defending the Alamo against the Mexicans in 1836. Travis was born near Red Bank, South Carolina, U.S.A. He was a teacher and practised law in Alabama before moving to Texas in 1831. He also led troops at Anahuac and San Antonio.

See also **Alamo.**

Travois is a device used by American Indians and other peoples for carrying loads. It consists of two poles, a net or platform lashed between, and a harness for hitching the device to a horse or dog. A travois has no wheels. The ends of the poles drag on the ground. See also **Transportation** (picture: Transportation in prehistoric times).

Trawl. See **Fishing industry** (Nets).

Treadmill is a wheeled mechanism rotated by people or animals walking on or inside the wheel. A treadmill with an axle is called a *wheel and axle* (see **Wheel and axle**). The movement of the wheel turns the axle and any mechanical device to which it is attached.

The ancient Romans used treadmills for such tasks as grinding grain, lifting water out of mines, and powering cranes that hoisted construction materials. People and such animals as cows and horses provided the power for these devices. Treadmills were used for heavy work until the 1700's and 1800's, when they were replaced by steam and hydraulic engines. Today, many people exercise indoors by jogging on a device that resembles a treadmill. Tiny treadwheels provide exercise for hamsters and other small pets in cages.

Treason originally meant disloyalty to a sovereign ruler, such as a king. People who criticized the ruler's policies and actions might find themselves convicted of treason. But today, the meaning of treason has changed. People in democratic countries can criticize the government, and work as freely as they like for the election of a new government. Treason is mainly confined to helping a foreign government wage war against one's own country. Death or life imprisonment is the usual penalty for treason. A person convicted of treason is usually called a *traitor*.

A traitor who was executed in England at the end of World War II was William Joyce, known as Lord Haw-Haw. Although he was born in the United States, he claimed to be British and held a British passport. During the war he made radio broadcasts from Germany, intending to lower the morale of the British people. In 1945, he was arrested and tried for treason. Because he owed allegiance to Britain while holding a British passport, he was convicted of treason and hanged.

Related articles in *World Book* include:

Arnold, Benedict
Brown, John
Dreyfus, Alfred
Quisling, Vidkun
Sedition

Treasure Island. See **Stevenson, Robert Louis.**

Treasure-trove is a term applied to articles containing a substantial amount of gold or silver that have been hidden and are later discovered in a house or in the earth. In the United Kingdom, all treasure-trove belongs by law to the Crown. The finder or the person who owns the land on which the treasure was found cannot keep the treasure, but receives a payment based on the value of the property found. In some countries the finder receives all the property. In others, half goes to the finder and half to the owner of the land. Anyone who finds treasure must report it to the police or a coroner who holds an inquest to discover whether the treasure has an owner or is treasure-trove.

Treasury. See **United Kingdom, Government of.**

Treaty is a formal agreement between two or more independent governments. It is usually a written document, but it may be a verbal statement agreed to by representatives of the countries. The history of treaty making goes back many hundreds of years. As early as 3000 B.C., rulers of ancient countries signed treaties with neighbouring kingdoms. The treaties served various purposes. Some treaties ended wars, and others settled boundary disputes. But throughout the history of the world, treaties have played an important part in the relations between countries.

Today, only sovereign states are able to make treaties. A sovereign state is one that is free from outside control. For example, Great Britain is a sovereign state because its government is free to make its own decisions. But the British colony of Gibraltar is not free to make its own decisions. It is therefore not a sovereign state, and cannot make its own treaties.

A treaty is much like a contract between private individuals. In both cases, the signing parties promise to do or not do some act. But there are important differences between treaties and contracts. A contract is not binding if one of the parties has forced the other party into agreement. But the use of force does not make a treaty void unless the force is actually used against the government representative who is working out the treaty terms. Unlike a private contract, a treaty does not go into effect until it is *ratified* (given formal approval). For example, a treaty between the United States and Great Britain is not official until it is approved by the United States Senate and by the British Crown.

There are several kinds of international agreements

Detail of a lithograph (mid-1800's) by Nathaniel Currier

A treaty signed by William Penn established friendship between colonists and American Indians in Pennsylvania. Penn agreed to pay the Indians for most of the land he claimed in their territory.

that have the force of treaties. One of these is called a *convention.* This is usually an agreement between states relating to a single topic, such as extradition. A *concordat* is an agreement between the pope and a sovereign state. An agreement between two monarchs on a private matter is not a treaty.

Kinds of treaties. Treaties may be divided into several classes according to their purposes, although international law recognizes no formal distinctions among treaties. A single treaty may include clauses under several classes. Some of the classes are described below.

Political. A peace treaty is one kind of political treaty. For example, the Treaty of Ghent in 1814 ended the War of 1812 in the United States. Others deal with alliances between countries and settle disputes. The Clayton-Bulwer Treaty in 1850 gave the United States and Britain equal protection rights in a future canal through Central America.

Commercial. These treaties include agreements on tariffs, navigation, fisheries, and consular services.

Confederation. Confederation treaties set up such international organizations as the Universal Postal Union.

Extradition. These treaties deal with escaped criminals. For example, let us suppose that two countries have signed an extradition treaty. If a criminal from one country flees to the other for safety, the criminal must be returned, or *extradited,* to stand trial for the crime.

Civil justice. These treaties protect a country's trademarks, copyrights, and patents in foreign countries. Some civil-justice treaties deal with the rights of aliens.

Negotiation. In monarchies, the king or queen and his or her legal agents have the power to make treaties and are represented at negotiations by a diplomatic agent, or *envoy.* For example, in Great Britain neither house of Parliament has any power over treaties. That power is reserved for the British Crown or Cabinet.

In republics, the chief executive usually has treaty-making power. This power is often subject to various restrictions. In the United States, the president may enter into a treaty with "the advice and consent" of the Senate. Two-thirds of the senators present must agree to the treaty terms. The Department of State carries on treaty negotiations. Sometimes the president enters into an *executive agreement* with a foreign country. This kind of agreement has the force of a treaty in international law, but it does not require the approval of the Senate.

Language used. Until the 1700's, all treaties were written in Latin. Then French became the official language. Today, most treaties are written in the various languages of the treaty-making nations.

Enforcement of treaties. In ancient times, a country had to "back up," or guarantee, its treaty promises. One way of doing this was to exchange hostages. Each country that signed the treaty would send one or more important people to the other countries that had agreed to the treaty. Hostages were held as prisoners. They could be killed if the terms of the treaty were not carried out.

The hostage system has not been used for many years. Today, most countries rely on the good faith of other countries, and on international public opinion. In many countries, treaties have the force of law. As a result, treaty provisions become legal requirements for officials. At the same time, however, nations may repeal or abolish treaties, as they do their own laws. But such actions are generally subject to certain international consequences.

Termination. Treaties may be ended in many ways. They may end upon the agreement of all parties concerned. Sometimes a treaty clause permits either party to cancel the agreement after due notice. The failure of one country to carry out its part of the agreement may cause the other country or countries to refuse to observe the treaty terms. A treaty becomes void when the physical conditions of the agreement become impossible to fulfil. War nullifies many treaties.

Ecclesiastical treaties deal with the religious rights of people who are living in a foreign country. Among Western nations, people may worship as freely in foreign lands as in their homelands. In several non-Christian parts of the world, Christian missionaries are permitted by treaty to teach the beliefs of Christianity. In some countries, ecclesiastical treaties permit foreign residents to practise their own religions but forbid them to try to convert others.

Related articles. The principal treaties among nations are listed in ***World Book*** under their respective titles, such as **Clayton-Bulwer Treaty; Ghent, Treaty of.** See also the following articles:

Arbitration
Extradition
International law
International relations
Protocol

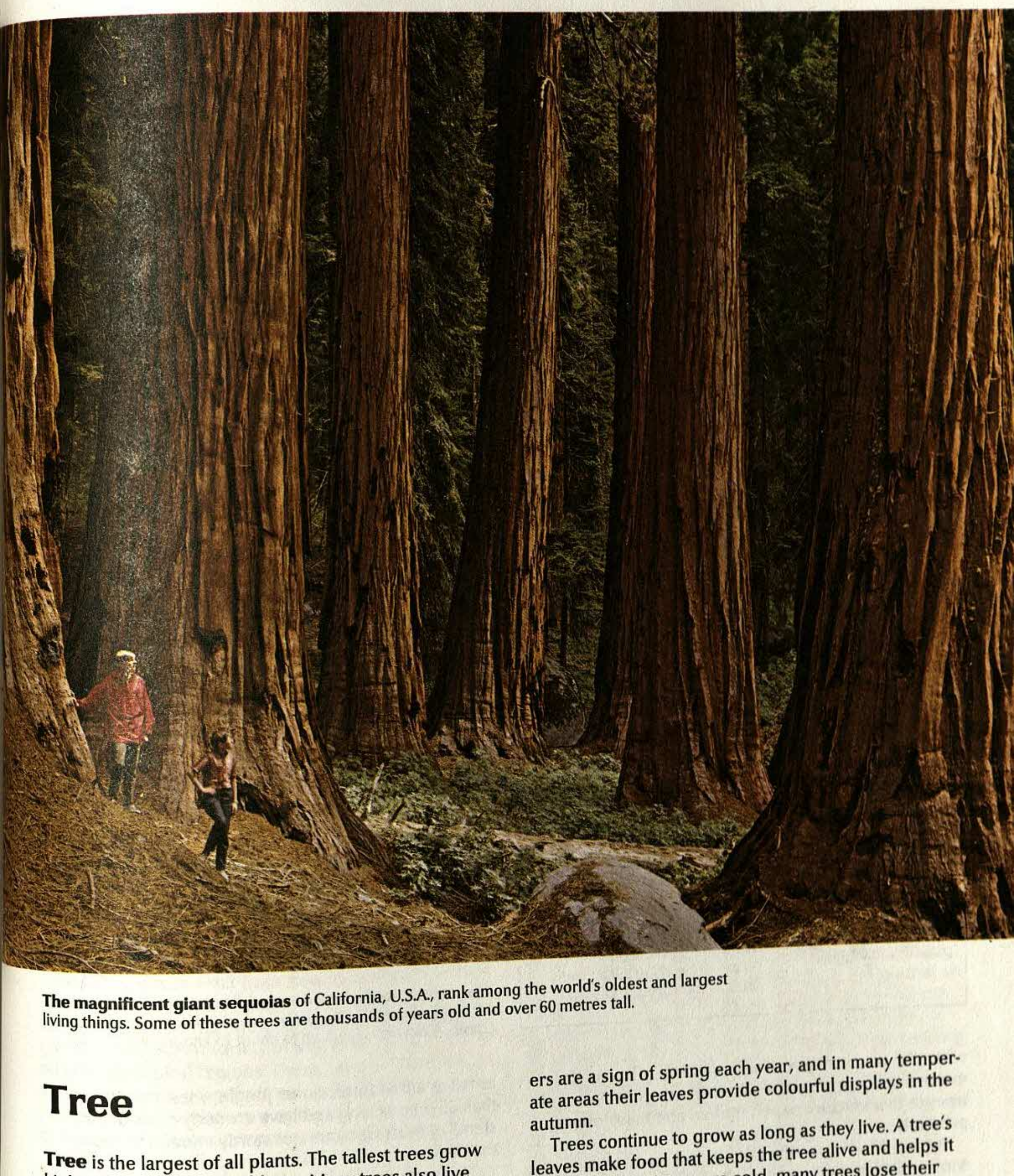
Treaty port. Over the years, foreign powers have used different methods to gain trading rights in China. One of these methods was to persuade the Chinese government to open certain Chinese seaports to foreign trade. These cities were known as treaty ports because trade with foreign countries was carried on under treaty agreement at these ports.

In 1842, China entered into a treaty-port agreement with Great Britain. This treaty opened five Chinese ports to British trade. The ports open to Britain were Guangzhou (Canton), Xiamen (Amoy), Fuzhou (Fu-chou), Ningbo (Ningpo), and Shanghai. Later, China signed treaty-port agreements with many other countries, including the United States, Germany, Russia, and Mexico. By 1894, there were more than 60 treaty ports in China. Most treaty-port agreements were forced upon China by foreign pressure or wars. Treaty ports gave many special privileges to foreign countries. The foreigners who enjoyed privileges in treaty ports could not even be punished under Chinese laws.

In 1912, China began to object to treaty-port agreements. After World War I, Russia gave up its rights in China, and in 1929 Mexico did the same. In 1943, both Great Britain and the United States signed treaties giving up their special rights in China. Today, China no longer has treaty ports.

See also **Extraterritoriality; Fuzhou; Guangzhou; Xiamen.**

Treble is the upper, or highest, part in choral music of two or more parts. It is often called the *soprano* part, and is sung by women or boys. The treble part in instrumental music is played by such instruments as the violin, flute, clarinet, and oboe. It is also played on the higher keys of the piano or organ, roughly above middle C. *Treble clef* or *G clef* (𝄞) is the sign used to mark the five-line staff from which treble voices or instruments read.



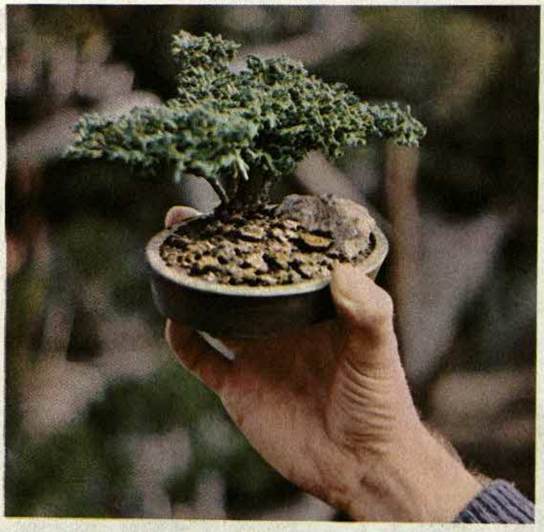
The magnificent giant sequoias of California, U.S.A., rank among the world's oldest and largest living things. Some of these trees are thousands of years old and over 60 metres tall.

Tree

Tree is the largest of all plants. The tallest trees grow higher than 30-storey buildings. Many trees also live considerably longer than other plants. Some trees live for thousands of years. They are the oldest known living things.

People do not think of trees the way they think of other plants, most of which grow for only a short time and then die. People think of trees as permanent features of the landscape. Year after year, large, old trees shade houses and streets from the sun and provide shelter for birds and other wildlife. Their buds and flowers are a sign of spring each year, and in many temperate areas their leaves provide colourful displays in the autumn.

Trees continue to grow as long as they live. A tree's leaves make food that keeps the tree alive and helps it grow. Where winters are cold, many trees lose their leaves in autumn. Other trees keep their leaves during the winter and so stay green all year long. Trees that shed their leaves in autumn rest during the winter. In spring, they grow new leaves and flowers. The flowers grow into fruit, which contain seeds for making new trees. Some tree fruits, such as apples and oranges, taste good. Fruit growers grow large amounts of these fruits for sale. Trees also make new wood each year



Dwarf trees never reach full size. Some, such as this miniature cypress tree, are deliberately kept small by a special pruning process. But many dwarf trees grow naturally in arctic regions.

The coconut palm provides wood and other building materials. The tree's nuts provide sweet-tasting milk and meat. Oil from dried coconut meat is used in making such products as margarine and soap.

Interesting facts about trees

The world's largest living thing is the General Sherman Tree, a giant sequoia in Sequoia National Park in California. It towers more than 83.8 metres and has a trunk about 11 metres wide. It probably dates from before 200 B.C.

The traveller's-tree, which grows in Madagascar, stores up to about 0.5 litre of water inside the base of each of its long leaf stalks. The tree received its name because it provided thirsty travellers with fresh drinking water.

The tallest trees are California's redwoods, which may tower more than 110 metres. Australia's eucalyptuses may grow more than 90 metres tall.

The thickest tree trunk is that of a Montezuma bald cypress near Oaxaca, Mexico. Its diameter exceeds 12 metres.

The baobab tree of Africa is one of the most useful trees. It has a huge trunk, which people hollow out to store water in or to live in. They eat the tree's leaves, fruit, seeds, and roots and use its parts in many other ways.

The oldest trees are California's bristlecone pines and giant sequoias. Some bristlecone pines have lived for between 4,000 and 5,000 years. The oldest sequoias are about 3,500 years old.

The banyan tree of India spreads by growing trunklike roots from its branches. In time, a banyan may cover a large area.

The ombu tree of Argentina is one of the hardiest trees. It can live with little water and can survive insect attacks, violent storms, and intense heat. The tree's wood is so moist it will not burn and so spongy it cannot be cut down.

The largest seeds are the nuts of the coco-de-mer, or double coconut palm, of the Seychelles, an island group in the Indian Ocean. A nut may weigh up to about 23 kilograms.

when the weather turns warmer. Wood is one of the most valuable products of a tree. Mills and factories use trees to manufacture paper, timber, and many other products.

A tree differs from other plants in four main ways. (1) Most trees grow at least 4.5 to 6 metres tall. (2) They have one woody stem, which is called a *trunk.* (3) The stem grows at least 8 to 10 centimetres thick. (4) A tree's stem can stand by itself. All other plants differ from trees in at least one of these ways. For example, no plant with a soft, juicy stem is a tree. Most of these plants, called *herbs,* are much shorter than most trees. *Shrubs,* like trees, have woody stems. But most shrubs have more than one stem, and none of the stems grows as thick or as tall as a tree trunk. Some jungle *vines* grow more than 60 metres long and have a woody stem. But the stems of most vines are not sturdy enough to support themselves.

There are thousands of kinds of trees. But most trees belong to one of two main groups—the *broadleaf trees* and the *needleleaf trees.* These two types of trees grow in Asia, Europe, North America, and many other parts of the world. The dominant trees of Australia, gums (eucalypts) and wattles (acacias), are mainly broadleaf trees. The native trees of New Zealand are also predominantly broadleaf. Most other types of trees, such as cycads, ginkgos, palms and tree ferns, grow mainly in warm regions.

Wood is one of the most useful tree products. In the above picture, a circular saw strips bark from a log at a sawmill. The stripped log will be cut into boards and other timber.

For thousands of years, trees have provided people with foods, fibres, and medicines. Above all, they have provided people with wood. Prehistoric people used wood to make the first spear, the first boat, and the first wheel. Throughout history, people have used wood to make tools, construct buildings, and create works of art. They have also used it for fuel. Living trees are as valuable to human beings as are tree products because they help conserve natural resources.

Wood products. Each year, woodmen cut down millions of trees in the world's forests. Logs from these trees are shipped to sawmills and pulp mills. Sawmills cut the logs into timber, which the building industry uses for many types of construction work. Manufacturers use timber to make everything from furniture to cricket bats. Pulp mills break down logs into wood pulp, the main raw material for making paper. The chemical industry uses wood pulp to make alcohol, plastics, and other products. See **Forest products; Timber.**

Food products. Fruit from trees is one of the oldest foods known to human beings. A selection of fruit and nuts can supply all the nutrients people need for life and growth. The greatest variety of fruit trees grow in tropical and subtropical regions. These trees produce such fruit as avocados, grapefruit, mangoes, and oranges. A number of these fruits serve as basic foods in some tropical lands. Cooler, temperate regions have fewer kinds of fruit trees. But several kinds are widely grown. For example, orchards in Europe and North America produce vast amounts of apples, cherries, and peaches. The most important nut tree of warm regions is the coconut palm, which produces coconuts. Nut trees of temperate regions include almonds, pecans, and walnuts. Trees also supply chocolate, coffee, maple syrup, olives, and such spices as cinnamon and cloves. See **Fruit; Nut.**

Other tree products include charcoal, cork, drugs, gums and resins, rubber, and tannic acid.

Charcoal is an important by-product of wood. It is partially burnt wood and consists mainly of carbon (see **Carbon**). It is used in many parts of the world for cooking or for heating. Charcoal is usually prepared in a kiln.

Cork comes from the spongy bark of cork oaks, which grow in some Mediterranean countries.

Drugs such as aspirin, quinine, and cocaine are products of trees. Aspirin is salicylic acid, obtained from the bark of willow trees. Quinine, which is used to treat malaria, is made from the bark of the cinchona tree. The cinchona tree is native to South America and is also grown elsewhere in the tropics.

Gums and resins are commercially important tree products. Gum arabic, used for gluing paper, is produced from the gum arabic tree. The gum arabic tree, a member of the mimosa family, is grown in the Middle East. Resin, a sticky fluid used in making turpentine, is harvested from pine trees in many parts of the world.

Rubber is refined from a white, milky substance called *latex,* which is obtained by *tapping* (cutting) the bark of the rubber tree. The rubber tree is native to the Amazon rainforest and is also grown on vast, commercial plantations in many other tropical locations.

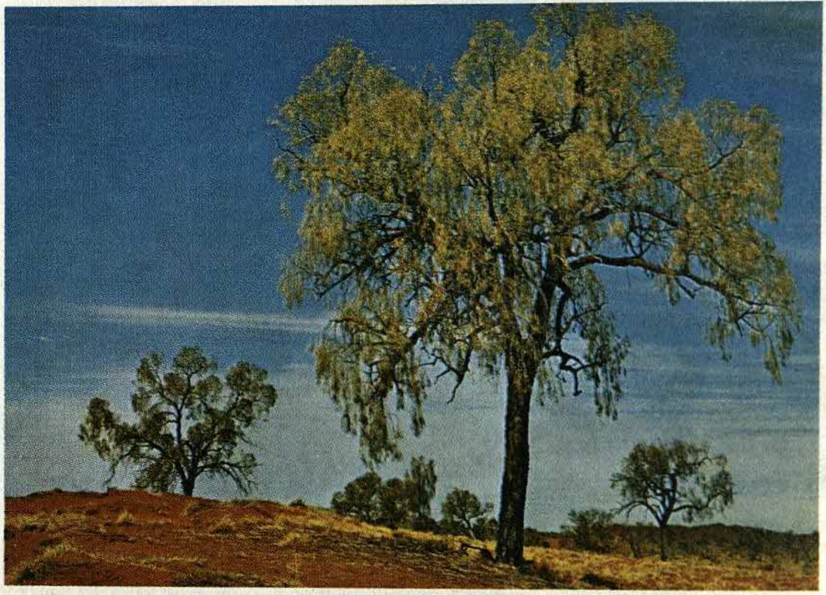
Tannic acid is used by the tanning industry to change animal hides into leather. It is obtained from the bark of oak and some other trees.

Other tree products include *coir,* a woody fibre that covers coconut shells. It is used in the Far East to make mats, baskets, coarse rope, and fabrics. *Kapok* is the floss that lines the seed pods of the "silk-cotton" tree of tropical Africa and Asia. It is widely used as insulation for anoraks and sleeping-bags, and as a filler in stuffed toys. The leaves of the carnauba palm of northern Brazil yield a wax used in the manufacture of polishes, matches, crayons, and plastics.

Trees in conservation. Trees help conserve soil and water. In open country, trees act as windbreaks and keep the wind from blowing away topsoil. Their roots also prevent soil from being washed away by heavy rains. Several species of trees have proved useful in halting the spread of deserts. One of these, the desert she-oak of Australia, is especially useful as it grows fast in sand. *Acacia* and *prosopis* trees, of the pea family, have also been planted extensively in arid regions. Apart from binding the sand together and thereby stabilizing the soil, they produce a large number of flowers that are attractive to honey bees and have edible pods that can be fed to livestock. Tree roots also help store water in the ground. In mountain regions, forests prevent sliding snow from causing avalanches.

Trees also provide an important source of food and shelter for wildlife. Insects feed on all parts of a tree, from the leaves and bark to the roots. Birds such as woodpeckers are dependent on trees for insects, and also nest in holes in trees. In the tropical forest, whole communities of animals live in the *canopy* (upper layer) of tall trees.

Trees help preserve the balance of gases in the atmosphere. A tree's leaves absorb carbon dioxide from the air. They also produce oxygen and release it into the atmosphere. These two processes are necessary for people to live. People could not survive if the air had too much carbon dioxide or too little oxygen.



Desert oaks grow in central and northwestern Australia. The timber that they yield is extremely hard and resistant to termites. Most trees in this area are small.

Kinds of trees

There are about 20,000 kinds of trees. They range from mighty forest trees to fragile ornamentals. The greatest variety of trees grow in wet tropical regions.

Scientists who study plants divide plants with similar characteristics into various groups (see **Plant** [Kinds of plants]). These scientists, called *botanists,* group each kind of tree with other plants that have certain features in common with it. Therefore, a group of plants may include certain trees, certain shrubs or vines, and certain herbs. For example, locust trees, broom plants, and clover all belong to the same *family.* These plants are grouped together because they reproduce in the same way and have similar flowers. On the other hand, some trees that look much alike, such as tree ferns and palms, belong to different groups of plants.

Trees also can be divided into six groups according to various features they have in common. These six groups are: (1) broadleaf trees; (2) needleleaf (or coniferous) trees; (3) palm, pandanus, and lily trees; (4) cycad trees; (5) tree ferns; and (6) ginkgo trees.

Broadleaf trees are the most numerous and varied trees. They include ashes, elms, maples, oaks, walnuts, willows, and many other familiar trees of the Northern Hemisphere, as well as the many eucalyptus species of Australia and New Zealand. They also include most trees of the tropics, such as mahogany trees and mangrove trees. In addition to their broad, flat leaves, broadleaf trees have other features in common. Almost all broadleaf trees of temperate regions are *deciduous*—that is, they lose their leaves each autumn. A few kinds of broadleaf trees in temperate regions do not lose their leaves in the autumn. These broadleaf *evergreens* include the holly trees and box trees of northern Europe. Some tropical broadleaf trees are deciduous, but most are evergreen. See **Deciduous tree; Evergreen.**

Foresters call broadleaf trees *hardwoods* because many of these trees, such as beeches, maples, and oaks, have tough, hard wood. Such wood makes excellent furniture. Some broadleaf trees, including limes and poplars, have soft, lightweight wood.

Broadleaf trees belong to a large group of plants called *angiosperms.* These plants have flowers which develop into *fruits* that completely surround the seeds. Fruits are the seed or seeds of a plant together with the parts in which they are enclosed. Botanists divide angiosperms into two groups—*monocotyledons* and *dicotyledons.* Monocotyledons produce seeds that contain one leafy structure called a *cotyledon* (see **Cotyledon**). These plants include palm, pandanus, and lily trees. Dicotyledons produce seeds that have two cotyledons. These plants include broadleaf trees. A few kinds of trees that do not have broad, flat leaves also belong to the dicotyledon group. An example is the saguaro cactus of the Southwestern United States, which has prickly spines. See **Angiosperm.**

Needleleaf (or coniferous) trees include firs, hemlocks, pines, redwoods, and spruces. Yew trees are also classified as needleleaf trees. There are about 650 species of needleleaf trees. Most of them have narrow, pointed, needlelike leaves. But a few types, such as cedars and junipers, have narrow, scalelike leaves.

Most needleleaf trees are evergreen, though they produce new needles each year. The oldest needles turn yellow or brown and drop, but the youngest needles remain green and do not fall. A few species of needleleaf trees are deciduous. One kind is the larch, which grows in northern forests. Another deciduous needleleaf tree is the Mexican cypress.

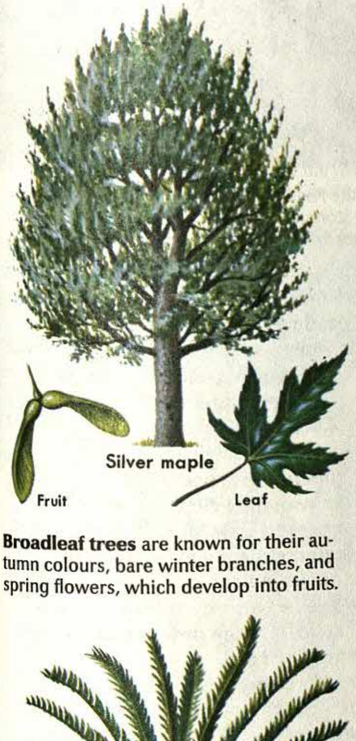
Foresters refer to needleleaf trees as *softwoods,* as most of them have softer wood than broadleaf trees have. But the wood of Douglas firs, yews, and some other needleleaf trees is hard.

Needleleaf trees belong to a group of plants called *gymnosperms.* Gymnosperms do not have flowers and their seeds are not enclosed to form fruits. Most gymnosperm trees bear their seeds in cones composed of hard scales. The seeds lie open on the surface of the scales. See **Conifer; Gymnosperm.**

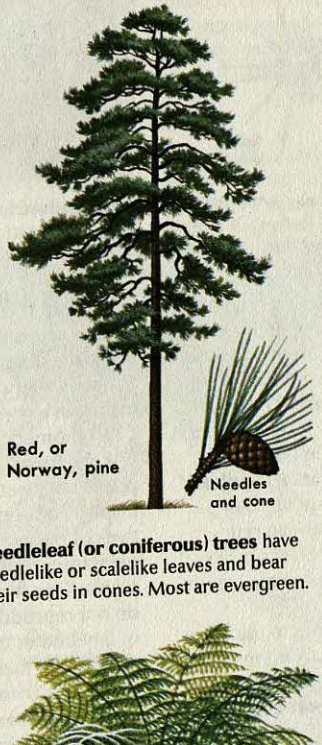
Most conifers grow north of the equator. They belong to four families—the pine, yew, cypress, and taxodium families. The *pine family* is by far the largest. It includes not only pines, but also such trees as firs, hemlocks, larches, and spruces. Pine trees make up a large *genus* (group of species) within the pine family. Best known of some 200 species in this family is the red-barked Scots pine. The *yew family* includes such well-known ornamental trees as English yews and Japanese yews. Yews do not produce cones but cup-shaped "berries." Many members of the *cypress family* have scalelike leaves and give off a spicy fragrance. The *taxodium family* includes bald cypresses and the largest of all trees: the redwoods and giant sequoias of western North America.

The six main groups of trees

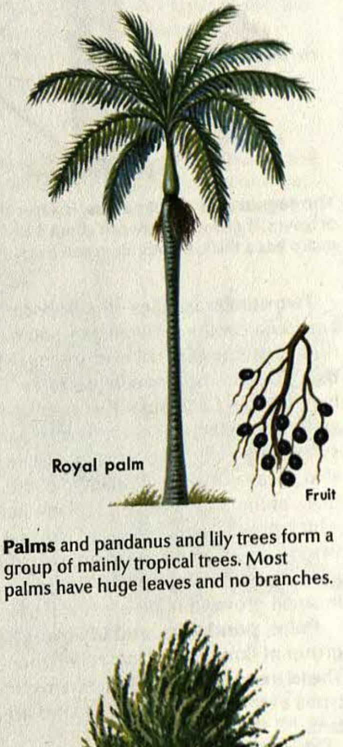
Trees can be divided into the six main groups illustrated below. All the trees in each group are similar in appearance and have other features in common.



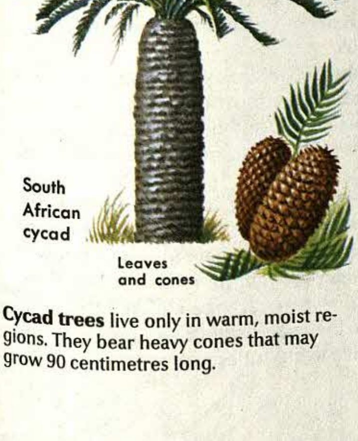
Broadleaf trees are known for their autumn colours, bare winter branches, and spring flowers, which develop into fruits.



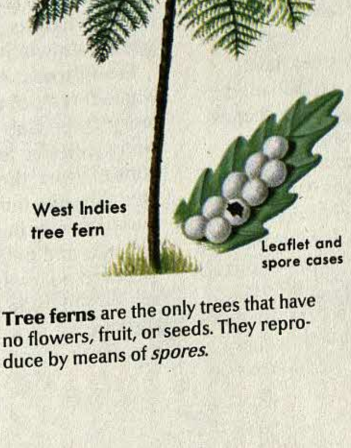
Needleleaf (or coniferous) trees have needlelike or scalelike leaves and bear their seeds in cones. Most are evergreen.



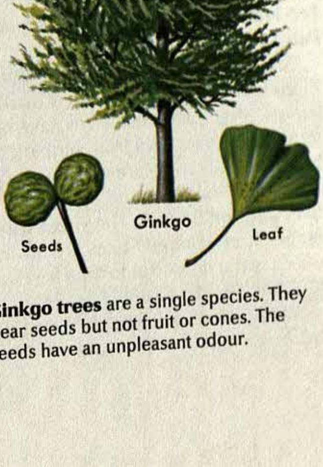
Palms and pandanus and lily trees form a group of mainly tropical trees. Most palms have huge leaves and no branches.



Cycad trees live only in warm, moist regions. They bear heavy cones that may grow 90 centimetres long.



Tree ferns are the only trees that have no flowers, fruit, or seeds. They reproduce by means of *spores.*



Ginkgo trees are a single species. They bear seeds but not fruit or cones. The seeds have an unpleasant odour.

The saguaro, or giant cactus, is a tree that has spines instead of leaves. It grows to between about 8 and 15 metres tall. The saguaro has a thick, woody stem and bears sweet fruit.

A prehistoric log in the Petrified Forest National Park of Arizona, U.S.A., turned to stone millions of years ago. Such *petrified* logs help us learn about the ancestors of today's trees.

Two conifer families—the *podocarpus family* and the *araucaria family*—grow mainly south of the equator. Podocarpus trees are tall evergreens with broader leaves than those of most needleleaf trees. The araucaria family includes the Chile pine. This strange-looking tree has snakelike branches covered with sharp, scaly leaves. It is sometimes called the monkey-puzzle tree because its sharp leaves make it difficult to climb. Native needleleaf trees of the Southern Hemisphere include the kauris, which grows almost as tall as North American redwoods. Southern Hemisphere needleleaf trees rarely form extensive woodlands. They occur as single trees or in small groves among broadleaf trees.

Palm, pandanus, and lily trees belong to the large group of flowering plants called monocotyledons. These trees grow mainly in warm climates. Of the three types of trees in this group, palms are the most important.

There are about 2,500 kinds of palm trees. They range from the coconut palms of tropical islands to the date palms of desert oases. Most palm trees have no branches. The trunk has a crown of enormous leaves. The leaves are either feather-shaped or fan-shaped. See **Palm.**

Unlike most palms, pandanus and lily trees have branches. Each branch has a crown of sword-shaped leaves. Most pandanus trees have tall *stilt roots* that extend into the ground from high on the trunk or branches. Lily trees are closely related to the garden flowers called lilies, and many of the trees have attractive, fragrant flowers. The yucca trees of Mexico and the far Southern United States are lily trees. The best-known yucca is the colourful Joshua tree found in the deserts of the Southwestern United States.

Cycad trees look much like palm trees. They have a trunk without branches and a crown of long, feathery leaves. But cycads are more closely related to pine trees than to palms. They produce seeds in cones that look like large pine cones. Millions of years ago, cycads grew in nearly every part of the world. Today, they grow mainly in a few warm, moist regions of Africa, Asia, and Central America. See **Cycad.**

Tree ferns. Ferns are best known as rather short plants with feathery, green *fronds* (leaves). But in the tropics and some areas with mild climates, many relatives of these plants are trees. Tree ferns look much like palm trees, but they belong to a different group of plants. Tree ferns do not have flowers or cones and so do not reproduce by seeds. They reproduce by means of tiny bodies called *spores,* which develop on the undersides of their fronds. See **Fern.**

Ginkgo trees are an extremely old species of tree. Millions of years ago, various kinds of ginkgoes existed. Only one species survives today. The ginkgo, like needleleaf trees, is a gymnosperm. But unlike other gymnosperm trees, the ginkgo has fan-shaped leaves. These leaves look like the fronds of a fern called the *maidenhair.* Ginkgoes are sometimes called *maidenhair trees.* They are natives of Asia, but many are grown in Europe and the United States.

Fossil trees. About 300 million years ago, there were whole forests of trees unlike most of the trees that grow today. Huge club-moss trees and horsetail trees grew along with tree ferns in steaming hot swamps. Over millions of years, the trees and other plants in the swamps died, became buried, and turned into coal. Elsewhere, buried forests became *petrified* (turned into stone). Coal deposits and petrified forests contain fossils of trees that died out more than 100 million years ago (see **Fossil**). Two of these extinct trees are the club moss tree and horsetail tree of the coal-forming swamps. The club mosses and horsetails living today are herbs.

The parts of a tree

A tree has three main parts: (1) the trunk and branches; (2) the leaves; and (3) the roots. The branches and leaves together are called the *crown.* The trunk supports the crown and holds it up to the sunlight. Tree ferns, cycads, and most palms have no branches. Their crowns consist only of leaves. The roots of most trees are hidden in the ground, but they may take up as much space as the trunk and crown do above the ground. Other important parts of a tree include the seeds and the seed-forming structures.

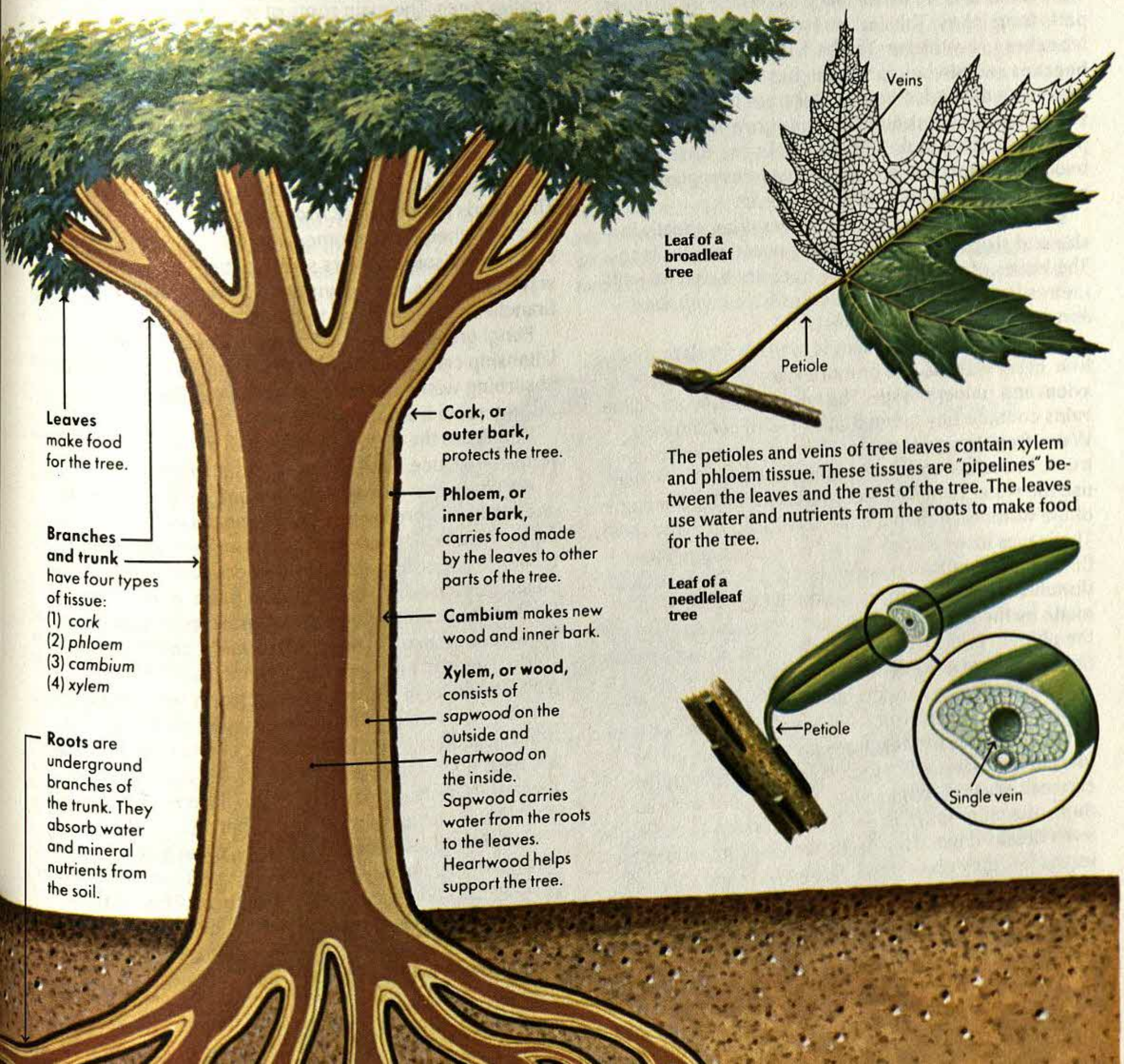
Trunk and branches give a tree its shape. The trunks of most needleleaf trees grow straight up to the top of the tree. The branches grow out from the trunk. On most needleleaf trees, the branches near the top are shorter than those farther down, which gives the crown a spirelike shape. The trunks of most broadleaf trees do not reach to the top of the tree. Instead, the trunk divides into spreading branches near the base of the crown, giving the crown a rounded shape. The trunks of a few broadleaf trees sometimes divide so close to the ground that the trees seem to have more than one trunk.

The trunks, branches, and roots of broadleaf and needleleaf trees consist of four layers of plant tissue wrapped around one another. These layers, working outwards from the centre of the tree, are: (1) the *xylem,* (2) the *cambium,* (3) the *phloem,* and (4) the *cork.*

The xylem is the woody, central part of the trunk. It has tiny pipelines that carry water with a small amount of dissolved minerals from the roots to the leaves. This water is called *sap.* The cambium, which surrounds the xylem, is a thin layer of growing tissue. Its job is to make the trunk, branches, and roots grow thicker. The phloem, also called the *inner bark,* is a layer of soft tissue surrounding the cambium. Like the xylem, the phloem has tiny pipelines. The food made by the leaves moves through the phloem to the other parts of a tree.

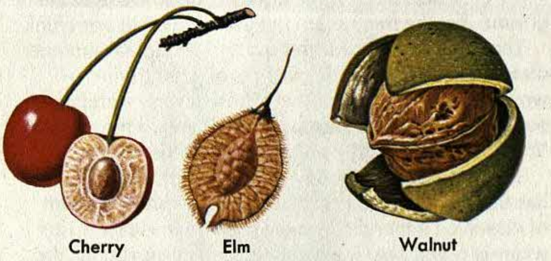
Parts of a tree

These diagrams show the three main parts of a tree: (1) the trunk and branches, (2) the leaves, and (3) the roots. The branches and leaves together make up a tree's *crown.* The diagrams also show the main types of tissue that compose most trees.

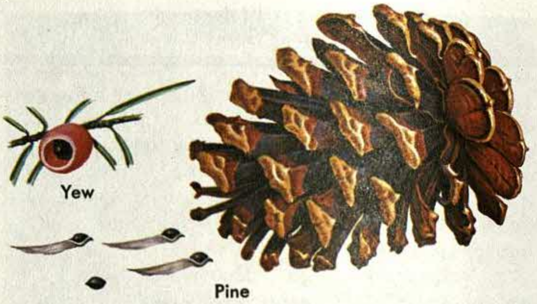

Leaves make food for the tree.
Branches and trunk have four types of tissue: (1) *cork* (2) *phloem* (3) *cambium* (4) *xylem*
Roots are underground branches of the trunk. They absorb water and mineral nutrients from the soil.
Cork, or outer bark, protects the tree.
Phloem, or inner bark, carries food made by the leaves to other parts of the tree.
Cambium makes new wood and inner bark.
Xylem, or wood, consists of *sapwood* on the outside and *heartwood* on the inside. Sapwood carries water from the roots to the leaves. Heartwood helps support the tree.
Veins
Leaf of a broadleaf tree
Petiole
Leaf of a needleleaf tree
Petiole
Single vein

The petioles and veins of tree leaves contain xylem and phloem tissue. These tissues are "pipelines" between the leaves and the rest of the tree. The leaves use water and nutrients from the roots to make food for the tree.

Seeds of broadleaf and needleleaf trees



Seeds of broadleaf trees, or *angiosperm seeds,* have protective coverings. The seed and covering together are called a fruit. Cherry and walnut seeds are enclosed in a pit or shell with a fleshy outer covering. Elm seeds have thin, winged coverings.



Seeds of needleleaf trees, or *gymnosperm seeds,* do not have protective coverings. The seeds of most needleleaf trees lie in cones and are released after the cones ripen. The yew and a few other coneless needleleaf trees have berrylike seeds.

In palms and tree ferns, the xylem and phloem are not separate layers. Instead, bits of xylem and phloem are connected and form small double pipelines scattered throughout the trunk.

The cork layer is the *outer bark* of a tree. It forms a "skin" of hard, dead tissue that protects the living inner parts from injury. The bark stretches to let the trunk and branches grow thicker. The bark of some trees, such as beeches and birches, is smooth because it stretches easily. But the bark of most other trees does not stretch so well. As the trunk and branches grow thicker, they push against the bark. It finally cracks and dries and so becomes grooved and rough. Most trees replace old bark from time to time with a new layer.

Leaves of various species of trees differ greatly in size and shape. Palms have leaves over 6 metres long. The leaves of some needleleaf trees are barely 10 millimetres long. Some broadleaf trees have *compound leaves* made up of small leaflets.

The main job of the leaves is to make food for the tree. Every leaf has one or more *veins,* which consist of xylem and phloem tissue. The tissue that surrounds the veins contains tiny green bodies called *chloroplasts.* Water from the roots passes through the xylem of the trunk, branches, and leaves to the chloroplasts, which use the water to make food sugar. Only a small amount of the water carried to the leaves is used to make sugar. The leaves lose most of the water to the atmosphere through *transpiration* (evaporation). Like the water and dissolved minerals carried from the roots, the food made by the leaves is also called *sap.* It travels through the phloem of the leaves, branches, and trunk to parts of the tree where it is needed. See **Sap.**

Almost all leaves are green in the spring and summer. Their colour comes from *chlorophyll,* a green substance in the chloroplasts. Most trees also have reds and yellows in their leaves. But the green of the chlorophyll conceals these colours. In late summer and early autumn, the chlorophyll in the leaves of many broadleaf trees breaks down. The leaves then die. But before the leaves fall, they reveal their hidden reds and yellows. After the chlorophyll breaks down, the leaves of many trees also develop scarlets and purples. See **Leaf** (The leaf changes colour).

Roots are long, underground branches of the trunk. They have the same layers of tissue as the trunk. The roots anchor a tree in the ground and absorb water with dissolved minerals from the soil. The main roots branch out into small roots, which, in turn, branch out into still smaller roots. The main roots of most trees begin to branch out 30 to 60 centimetres under the ground. Some trees have one main root larger than the others. This root, called a *taproot,* extends straight down 5 metres or more.

A tree develops millions of small roots. Each root grows longer at its tip, which is as small as a thread. As a root tip grows, it pushes through particles of soil. Thousands of fine, white *root hairs* grow just behind the root tip. When the tip comes into contact with drops of water in the soil, the hairs soak up the water and dissolved minerals. The xylem layer of the roots, trunk, and branches carries this sap to the leaves.

Fungi grow on the roots of most trees in a helpful relationship called *mycorrhiza.* The fungi aid the roots in absorbing water and mineral nutrients. They also protect the roots from some diseases.

Seeds are the means by which all trees except tree ferns reproduce. Tree ferns reproduce by spores.

Angiosperms—broadleaf trees and palm, pandanus, and lily trees—produce seeds by means of flowers. Some broadleaf trees, such as horsechestnuts and magnolias, produce large, showy flowers. Many others have small, plain-looking flowers. Most palm, pandanus, and lily trees have small flowers that grow in bunches. Sometimes these are brightly coloured and fragrant.

The seeds of angiosperms are enclosed to form a fruit. The fruits of some broadleaf trees, such as apples and cherries, have a fleshy outer covering. The fruits of other broadleaf trees, including acorns and beechnuts, are hard nuts. Ashes, elms, and maples have thin, winged fruits. Palm, pandanus, and lily trees have a variety of fruits, ranging from nuts to berries.

Gymnosperms—needleleaf trees, cycads, and ginkgoes—do not have flowers or fruit. Their seeds are produced in cones or similar structures. The seeds of needleleaf trees and cycads have no protective coverings. Ginkgo seeds have a fleshy outer covering, but the covering is not a true fruit.

How a tree grows

Most trees begin life as a seed. The young tree that develops from this seed is called a *seedling.* After a tree reaches a height of 1.8 metres or more and its trunk becomes 2.5 to 5 centimetres thick, it is called a *sapling.* Many trees reach a height of more than 30 metres. Some old trees have trunks more than 3 metres in diameter.

Trees need great amounts of water. A large apple tree in full leaf may absorb 360 litres from the soil daily. Most of the water goes to the leaves. On a sunny summer day, some trees move water up through their trunks at the rate of 90 centimetres per minute. A tree's wood is about half water.

How seeds sprout into trees. A seed contains parts that develop into the trunk and roots of a tree. It also has one or more cotyledons and a supply of plant food. After a seed has left the parent tree, it rests for a while on the ground. Water, air, and sunshine help the seed *germinate* (begin to grow). The part of the seed that develops into the trunk points upward toward the sunlight. As the seed absorbs water, the root part swells and bursts through the seed's shell. As the root grows, it pushes down into the soil. The food stored in the seed nourishes the tree. As the root begins to soak up water from the soil, the trunk begins to develop leaves.

How leaves make plant food. As a leaf develops, it gets sap from the roots. It also absorbs carbon dioxide from the air. The leaf uses the energy of sunlight to change the sap and carbon dioxide into sugar, a process called *photosynthesis.* The sugar provides food for the trunk, branches, and roots. During photosynthesis, the leaves also produce oxygen and release it into the atmosphere. See **Leaf** (How a leaf makes food).

How trees grow taller. Trees grow taller only at the tips of their trunk and branches. Each year, the tip of the trunk and of each branch develop a *bud.* The bud contains a tiny leafy green stem called a *shoot.* The bud is wrapped in a protective covering of *bud scales.* After a period of rest, the buds swell and open. The shoots that were inside the buds begin to grow and so make the trunk and branches taller. Another type of bud grows on the sides of the trunk and branches. These buds contain a shoot that develops into a leaf-bearing *twig* after the bud opens. As a twig grows larger, it becomes another branch of the tree. Some tree buds develop into flowers. Still others develop into twigs that bear both leaves and flowers. In warm climates, trees produce buds frequently during the year or continue to grow without forming buds. In colder climates, trees produce buds only in the summer. These buds rest through the winter and open after warm weather arrives in spring.

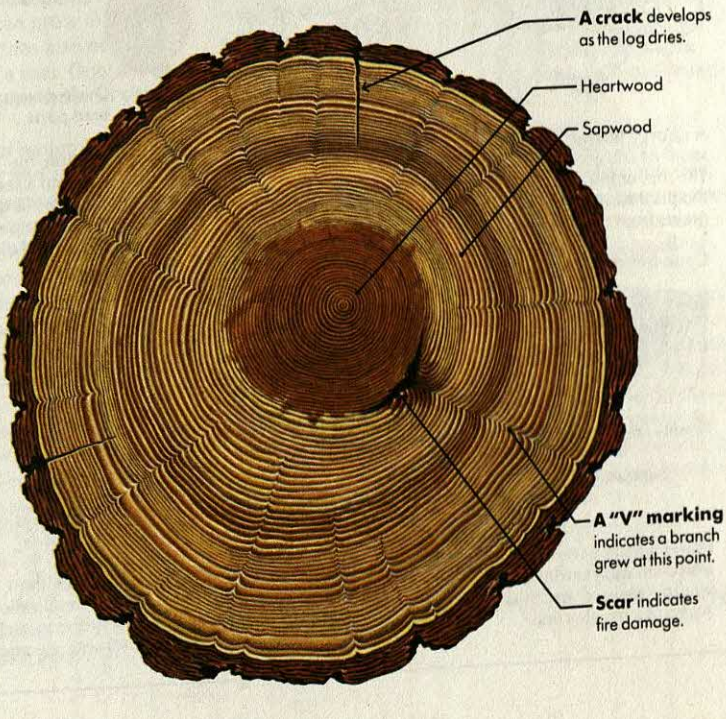
Trees without branches—cycads, most palms, and tree ferns—grow somewhat differently. For example, a young palm tree does not grow taller for a number of years. Its short trunk thickens and produces more and larger leaves each year. After the trunk and crown reach adult size, the tree begins to grow taller. The trunk stays about the same thickness for the rest of the tree's life.

How trunks and branches grow thicker. The trunk and branches of a broadleaf or needleleaf tree grow thicker as long as the tree lives. The cambium tissue just underneath the inner bark causes this thickening. It uses the sugar produced by the leaves to make new plant tissue. On its outside, the cambium makes new phloem, or inner bark, and on its inside, new xylem, or wood.

Wood consists largely of *cellulose,* a tough substance made from sugar. The xylem has two kinds of wood—*sapwood* and *heartwood.* The wood nearest the cambium is the sapwood. It is living wood and contains the tiny pipelines that carry sap. In tropical climates, the sap-

How a tree reveals its history

Most trees in temperate regions grow a layer of wood each year. After such a tree has been cut down, the layers can be seen as rings in the trunk. These *annual rings* reveal the tree's life story. The pine log in this drawing has 72 annual rings, showing that the tree lived for 72 years.


A crack develops as the log dries.
Heartwood
Sapwood
A "V" marking indicates a branch grew at this point.
Scar indicates fire damage.

Narrow centre rings indicate that other trees shaded the young tree, depriving it of moisture and sunlight.

Wider rings on the log's lower side after the 30th year show that the tree was slightly bent in this direction. The tree then began to grow more wood on this side than on the other to keep from falling. Most rings after the 38th year are wider than the centre rings. This indicates that many surrounding trees had been removed, giving the tree more moisture and sunlight. Differences in the width of rings after the 38th ring were caused mainly by varying amounts of rainfall from year to year.

wood thickens all year. In cooler climates, a new layer of sapwood usually forms only in early summer. As a tree ages, the wood nearest the centre dies. This dead wood is the heartwood. It helps support the tree.

In regions where trees make a new layer of wood once a year, the layers form a series of *annual rings.* Each ring represents one year's growth. After such a tree has been cut down, a person can count the rings to determine the tree's age. Scientists have also found that slight changes in the composition of a tree's cellulose reveal the kind of weather that a tree experienced.

How trees reproduce. Most trees reproduce sexually. That is, seeds are produced only after sperm unite with eggs. Sperm are produced by pollen, which forms in the tree's male reproductive parts—either the male part of the flower or the male cone. Eggs form in the female part of the flower or in the female cone. Among many angiosperm species, the flowers have both male and female parts. The pollen from the male part can simply drop onto the female part. Other angiosperms and all gymnosperms have separate male and female flowers or cones, which may grow on the same tree or on separate trees. The pollen of these species is carried to the female flower or cone by insects, the wind, or other means. After contacting the female flower or cone, pollen produces sperm. The sperm then unite with eggs, and one or more seeds develop within a fruit or cone.

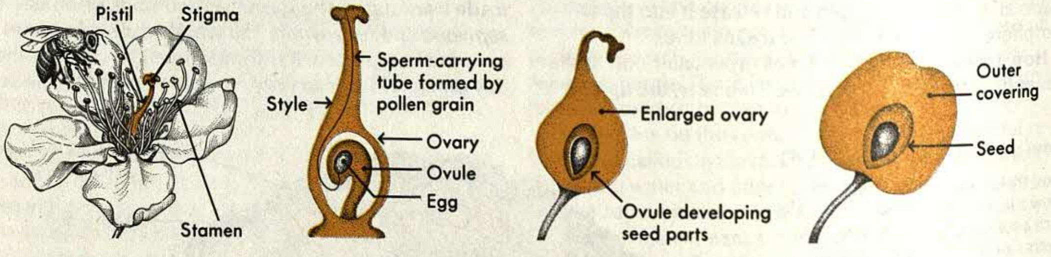
When the fruit or cone has ripened, the seeds are ready to leave the tree. The wind scatters the seeds of needleleaf trees and the winglike seeds or fruit of such broadleaf trees as ashes, maples, poplars, and willows. Birds, squirrels, and other animals scatter seeds contained in nuts or fleshy fruits. Sea currents sometimes carry the seeds of coconut palms and mangroves.

Trees can also reproduce by a process called *vegetative reproduction.* After a tree has been cut or blown down, the stump may develop green sprouts. In time, one or several of these sprouts can grow into trees. A clump of birches or tulip trees may be produced in this way. The roots of apple trees, aspens, and some other trees sometimes develop shoots called *suckers* that may also grow into trees. Some spruces found in bogs grow roots from their branches. This method of reproduction is called *layering.* In addition, nursery workers often grow trees from *cuttings*—that is, twigs cut from older trees. The twigs are planted and develop roots.

How most trees reproduce

Most trees reproduce by means of sex organs in their flowers or cones. Pollen from male organs produces sperm, which *fertilize* (unite with) eggs in female organs. This union produces seeds.

Fruit-bearing trees, or *angiosperms,* have flowers with an *ovary,* which becomes the outer part of the fruit.


Pistil
Stigma
Stamen
Sperm-carrying tube formed by pollen grain
Style
Ovary
Ovule
Egg
Enlarged ovary
Ovule developing seed parts
Outer covering
Seed

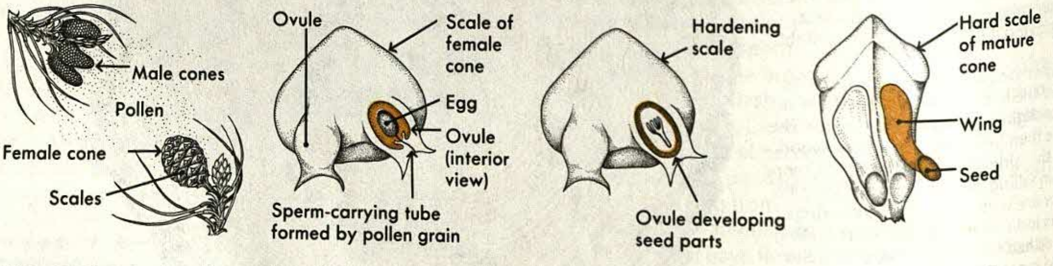
A cherry flower has male *stamens* and a female *pistil.* The top, or the *stigma,* of the pistil receives pollen grains from the stamens.

The pistil has an immature seed, or *ovule,* in an *ovary.* A sperm from a pollen grain moves down the *style* and fertilizes the egg.

After fertilization, the ovule develops into a seed, and the ovary grows larger. The other parts of the pistil and flower wither and die.

The fruit has an outer covering formed from the ovary. The seed or seeds are inside. A seed will develop into a new tree.

Cone-bearing trees, or *gymnosperms,* have cones without an ovary.



Pine cones are male or female. The wind carries pollen from male cones to the *scales* of a female cone.

A scale has two ovules, which are not enclosed in ovaries. Pollen enters the ovules and produces sperm.

After pollination, the scales harden. Fertilization occurs as a sperm in each ovule unites with the egg.

The seed produced from each fertilized ovule has the parts for a new tree. The seeds develop long wings.

Forests of broadleaf trees, or *hardwood forests,* grow in many parts of the world. This forest is in Germany. In temperate regions, most broadleaf trees lose their leaves each autumn.

Trees around the world

In some parts of the world, trees grow in thick forests. In other regions, they do not grow at all. To grow, trees need a period of more than two months without frost each year. The few trees that grow in the Arctic never reach full tree size. No trees can grow in the ice and bitter cold of Antarctica. Most trees also need at least 40 to 50 centimetres of rainfall a year. Only a few trees, such as the Joshua tree and some types of palms, can survive in deserts.

Most broadleaf trees grow best in regions that are warm and moist for at least three or four months of the year. Colder, dryer climates are better suited to most needleleaf trees. But some broadleaf trees, such as birches and willows, grow well in cool climates. Some needleleaf trees, including bald cypresses and various types of pines, need fairly warm climates. Palm trees grow in warm areas throughout the world, especially the wet and the dry tropics. Pandanus trees, cycads, and tree ferns grow mainly in the wet tropics and other warm, moist regions. Lily trees also thrive in warm areas, but they do not need as much moisture as do pandanus trees, cycads, and tree ferns.

Different kinds of trees also require different soils. Many needleleaf trees grow well in poor, sandy soil. But most broadleaf trees need more fertile soil.

Some trees grow alone or in small groups. Where moisture is scarce, trees may grow only along riverbanks. Tree seeds carried by sea currents may take root along shorelines. People plant individual trees in such places as parks and gardens. But most trees by far grow in forests. The world's forest regions consist chiefly of broadleaf and needleleaf trees.

Broadleaf forests grow in regions that have a fairly long growing season and plentiful rainfall. Every continent except Antarctica has broadleaf forests, which are also called *hardwood forests.* In areas with cold, snowy winters, almost all the trees in broadleaf forests lose their leaves each autumn. In tropical areas, most broadleaf trees are evergreen.

In the past, broadleaf forests covered much of the Northern Hemisphere. They included such trees as ashes, birches, beeches, and oaks. Over the centuries, most of the trees in these forests were cut down to provide timber and fuel and to make room for farms and cities. Today, only a few regions have large broadleaf forests.

Broadleaf forests made up largely of quaking aspens and balsam poplars cover large areas of southern Siberia and parts of southern Canada. Temperate deciduous forests of birches and oaks grow in Eastern Europe and along the Yellow Sea coast of China and Korea. In Australia, eucalyptus and acacia trees dominate the landscape. Eucalyptus trees are among the tallest trees in the world. Some eucalyptus trees are more than 90 metres tall.

In many areas, *mixed forests* of broadleaf and needleleaf trees grow alongside broadleaf or needleleaf forests. Central and southern Europe, central Canada, the eastern United States, and eastern Asia all have large mixed forests.

Tropical rainforests grow in Uganda, *above,* and in other hot, wet areas. Most of the trees are broadleaf and evergreen. Although they look alike, they belong to many different species.

Tropical rainforests. Remarkable broadleaf forests grow in tropical regions where the weather is always hot and rain falls regularly every month of the year. In these tropical rainforests, many of the trees look alike. They are tall, and many tower more than 45 metres. The trees have leathery, dark-green leaves. Because the trees receive plenty of moisture throughout the year, most of them are evergreen. The trees may thus look alike, but they belong to many species. Many palms grow among the broadleaf trees in the tropical rainforests.

The largest rainforests are in South and Central America, central Africa, and Southeast Asia. In many countries in these regions, the rainforest is being systematically destroyed in order to satisfy worldwide demand for timber or to clear land for farms and cities. In the late 1980's, tropical rainforests covered about 10 million square kilometres. About 100,000 square kilometres of rainforests are destroyed each year.

Commercial *logging* (cutting down trees for timber) causes tremendous environmental damage. Cutting down the larger trees often also brings down the smaller trees and the heavy machinery used tears up vegetation.

Tropical trees are cut down to provide substitutes for high-value temperate timbers, such as beech, oak, and walnut. Tropical hardwoods also have structural and decorative properties which temperate trees do not have.

The timber trade handles only a few species of tropical trees. In the Amazonian forest, only about 50 species (out of many thousands) are used. In Africa, 10 per cent of the available species account for 70 per cent of all timber exports. Southeast Asia has an export timber trade which concentrates on about 12 species of trees. Gabon, a country in West Africa, bases 90 per cent of its export trade on one species, the *okoumé.*

The cutting down of hardwood trees is threatening certain species with extinction. Species at risk include familiar and valuable tropical hardwoods, such as teak; teak substitutes; beech substitutes; and mahogany and other tropical redwoods.

Teak is one of the best-known tropical trees, and also one of the most expensive. With a strength roughly equivalent to oak, teak can be shaped fairly easily. For centuries it was used for boat building. Teak is now increasingly rare in its native areas, the monsoon forests of Southeast Asia, and is being grown in commercial plantations.

The scarcity and high cost of teak has led to the use of other timbers with similar characteristics. The leading teak substitute is *afrormosia,* which grows in West and Central Africa. But after 40 years of being exported, this high-value tree now faces extinction. Unlike teak, afrormosia is a very slow-growing species.

For many years *iroko,* which has a fine-grained, heavy wood, was sold internationally under the name "West African teak". It has now become something of a rarity. At the present rate of being cut down, the iroko tree will have become extinct by the end of the 1990's.

Another decorative timber of high quality is *Borneo teak.* It has dark, reddish-brown wood, which is used for furniture, window frames, and parquet floors. Except in Indonesia and Papua New Guinea, most natural forests of Borneo teak have been severely depleted.

Forests of needleleaf trees, or *softwood forests,* cover huge areas in the far north as well as the slopes of such mountain ranges as the Italian Alps, *above.*

Timber traders turned to the tropics for substitutes for *European beech.* This drastically reduced the numbers of such common species as the West African *obeche* and the Indonesian *ramin.* Nigeria banned the export of obeche in 1975.

One of the original prizes of the New World, *Cuban mahogany,* or small-leaf mahogany, was recognized as an excellent timber species by the invading Conquistadors. The larger ships of the Spanish Armada were built of this tough, close-grained timber. Different growing conditions produce colour variations in the wood, but nearly all mahogany tends to mature to a rich, dark, reddish-brown, with a golden lustre. Apart from its beauty, mahogany is valued for being easy to work and for its resistance, once seasoned, to splitting or warping.

All mahoganies are now under severe threat. Hardly any natural-growing small-leaf mahogany is left. In the late 1980's, the Brazilian government used armed guards to prevent the removal of mahogany logs from Indian reserves.

Timber traders tend to call many tropical redwoods mahogany, though they are not true mahoganies. They are generally more brittle than true mahoganies. The *dipterocarp* species, which forms the bulk of Southeast Asian exports, has many local names. The same or similar timbers may be known as Philippine mahogany or *lauan* in the Philippines, as *seraya* in Indonesia, and as *maranti* in western Malaysia.

West African mahogany-like timber known as *khaya,* or red mahogany, has been selling in Europe since the mid-1800's. The varieties of timber resemble true mahoganies and are in great demand. Ghana had to ban the export of five species to prevent their extinction. *Acajou,* the main timber export of Ivory Coast, remains under severe threat.

Conserving tropical rainforests. There are no effective measures for controlling the trade in timber of tree species threatened with extinction. One problem is that there are little data on the effects of logging on individual timber species.

In the 1980's, some timber-producing countries took steps to safeguard their natural heritage. Nigeria, Ghana, the Philippines, Malaysia, and Indonesia all introduced measures to restrict timber exports. Thailand imposed an outright ban on logging in 1988. Improved forest management and the development of tropical timber plantations are among the long-term goals of conservationists. Both are important aspects of the International Tropical Timber Agreement, which came into effect in April 1985.

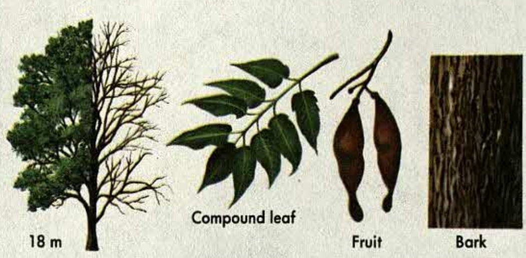
Needleleaf forests grow mainly in regions that have long, cold winters. These forests, which are also called *softwood forests,* stretch across northern Europe, Siberia, and Canada. Many firs, larches, and spruces grow in these northern forests, along with a few broadleaf trees, such as birches and willows. Some willows grow even farther north than needleleaf trees do. But they seldom reach more than shrub size. Needleleaf forests also blanket slopes in such mountain ranges as the Alps and the Rocky Mountains.

A few needleleaf forests grow in warmer regions. For example, the Southeastern United States has large forests of pines. These forests provide great quantities of wood for timber and wood pulp.

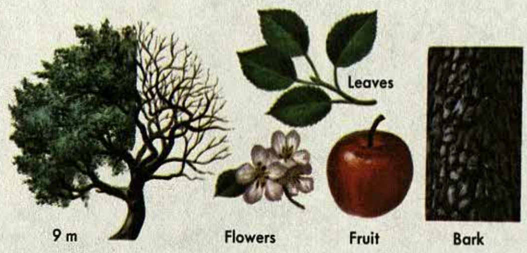
Familiar broadleaf and needleleaf trees

Broadleaf trees of the Northern Hemisphere

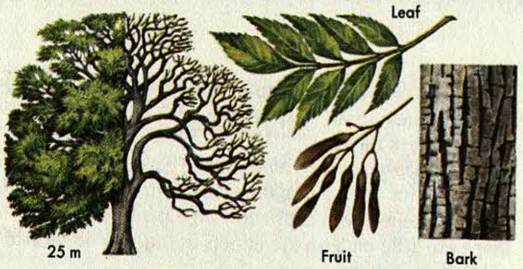
Ailanthus, or **tree of heaven** *(Ailanthus altissima).* Range—native to China; widely planted in other countries.



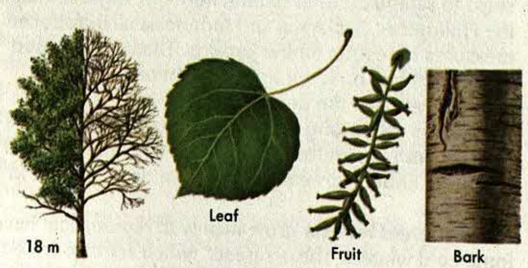
Apple, Common *(Malus pumila).* Range—native to Europe, southern and southwestern Asia; widely planted in other countries.



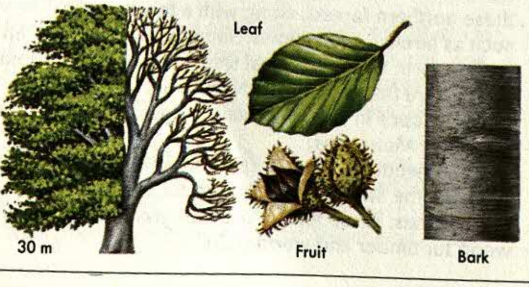
Ash, Common *(Fraxinus excelsior).* Range—Europe.



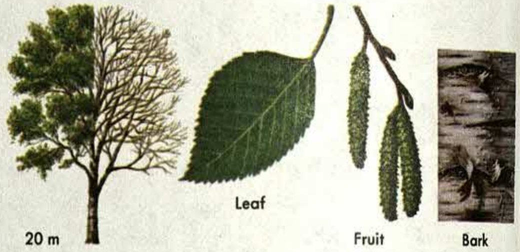
Aspen, Quaking *(Populus tremuloides).* Range—most of Northern and Western U.S.A., including Alaska; most of Canada.



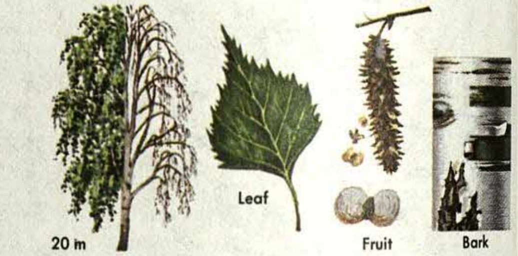
Beech *(Fagus sylvatica).* Range—Europe.



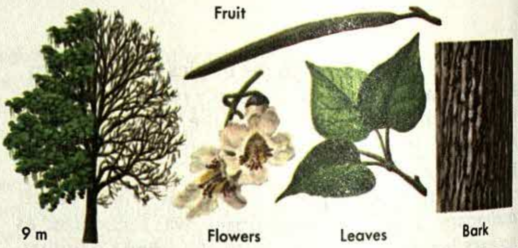
Birch, Paper *(Betula papyrifera).* Range—northernmost U.S.A. and Alaska; most of Canada.



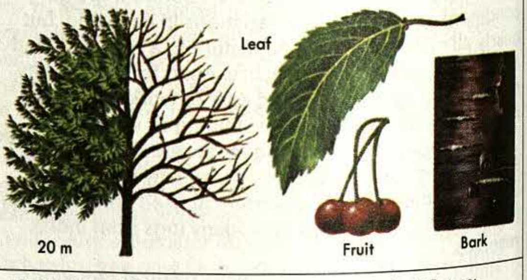
Birch, Silver *(Betula pendula).* Range—Europe.



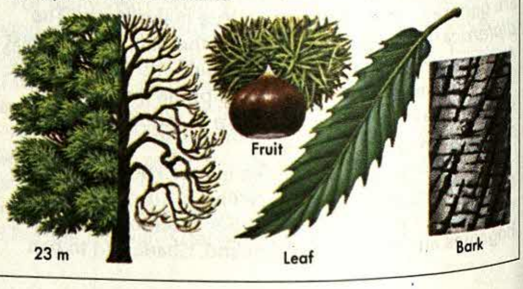
Catalpa, Northern *(Catalpa speciosa).* Range—native to central Mississippi Valley, U.S.A., but found throughout the eastern U.S.A.



Cherry, Wild *(Prunus avium).* Range—Europe, North America.

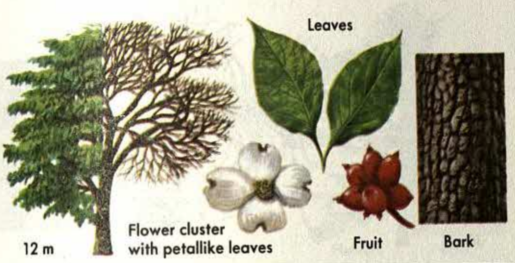


Chestnut, Sweet *(Castanea sativa).* Range—native to southern Europe; widely planted in other countries.

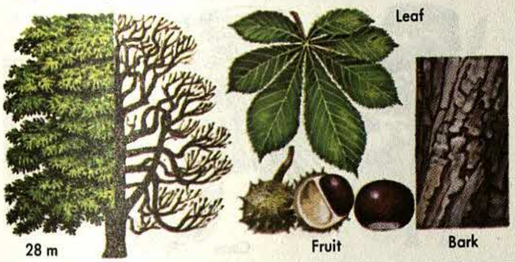


Broadleaf trees of the Northern Hemisphere

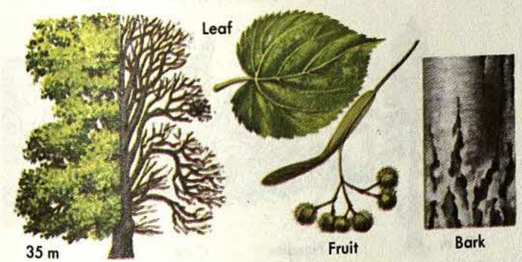
Dogwood, Flowering *(Cornus florida).* Range—most of Eastern U.S.A. and southwestward into Texas; southernmost Ontario, Canada.


Leaves
Flower cluster with petallike leaves
Fruit
Bark
12 m

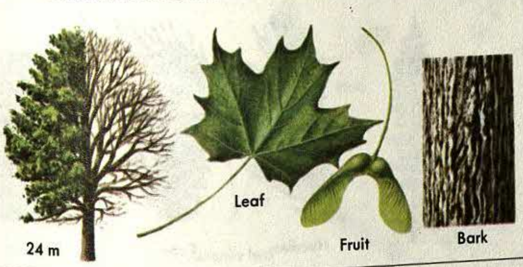
Horse chestnut *(Aesculus hippocastanum).* Range—native to Greece; common throughout western Europe; widely planted in other countries.



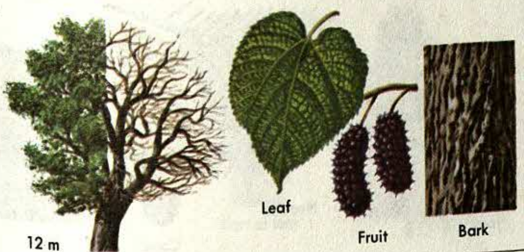
Lime, Common *(Tilia europea).* Range—Europe.



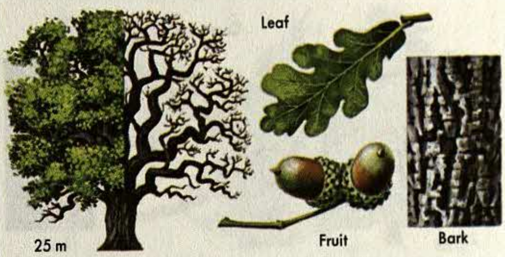
Maple, Sugar *(Acer saccharum).* Range—northeastern quarter of U.S.A. and southward into Georgia and northward into Canada.



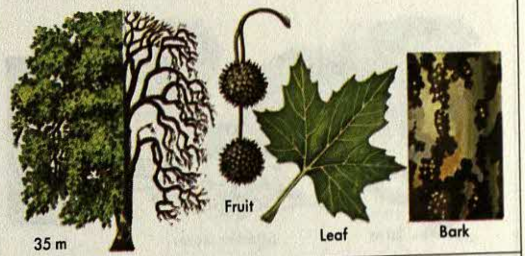
Mulberry, Red *(Morus rubra).* Range—Eastern half of U.S.A. except upper New England and upper Midwest.



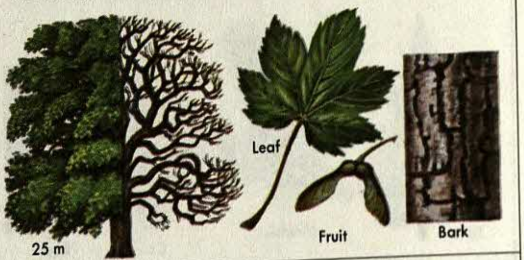
Oak, Common or pedunculate *(Quercus robur).* Range—Europe.



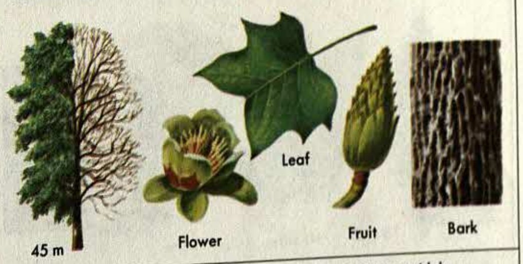
Plane, London *(Platanus x acerifolia* or *P. x hispanica).* Range—native to southern Europe; planted in western Europe, and southern Britain.



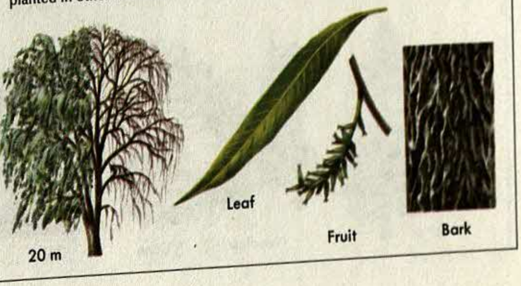
Sycamore *(Acer pseudoplatanus).* Range—native to central Europe; common throughout Europe; widely planted in other countries.



Tulip tree *(Liriodendron tulipifera).* Range—Southern U.S.A. and into Northeast and Midwest; southern Ontario, Canada.



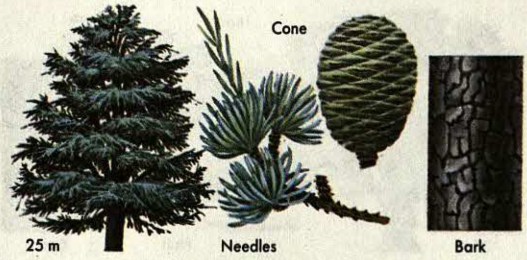
Willow, Weeping *(Salix babylonica).* Range—native to China; widely planted in other countries.



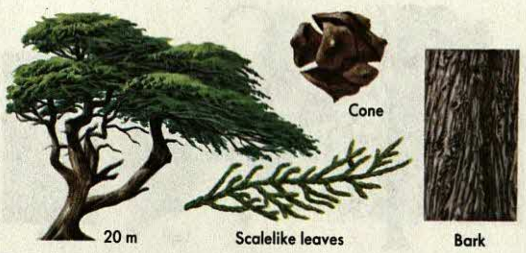
Familiar broadleaf and needleleaf trees (continued)

Needleleaf trees of the Northern Hemisphere

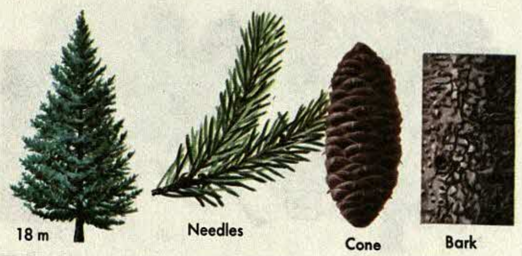
Blue cedar *(Cedrus atlantica glauca).* Range—native to North Africa; widely planted in other countries.



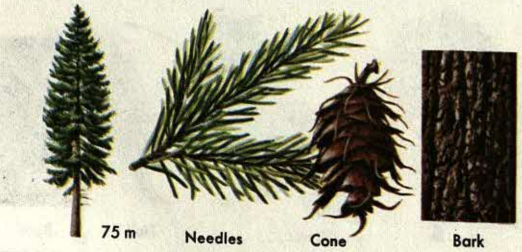
Cypress, Monterey *(Cupressus macrocarpa).* Range—Monterey County, California, U.S.A.



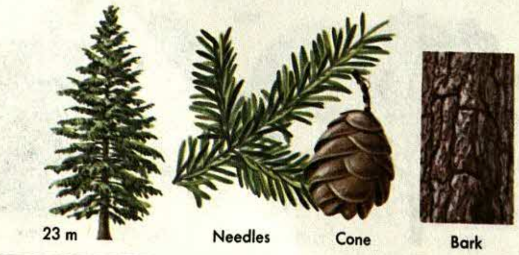
Fir, Balsam *(Abies balsamea).* Range—most of eastern Canada and northwestward into Alberta and southward into Eastern U.S.A.



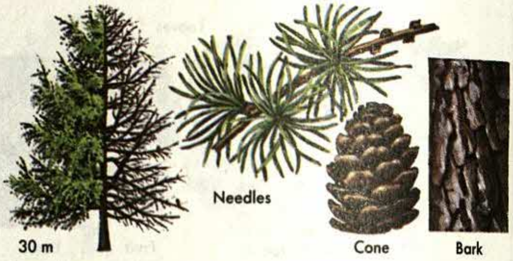
Fir, Douglas *(Pseudotsuga menziesii).* Range—chiefly Pacific coast and Rocky Mountain regions of U.S.A. and Canada.



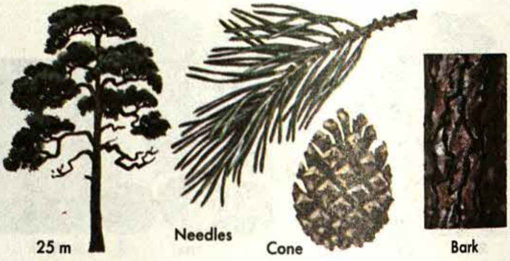
Hemlock, Eastern *(Tsuga canadensis).* Range—southern Canada to the Appalachian and Great Lakes regions of U.S.A.



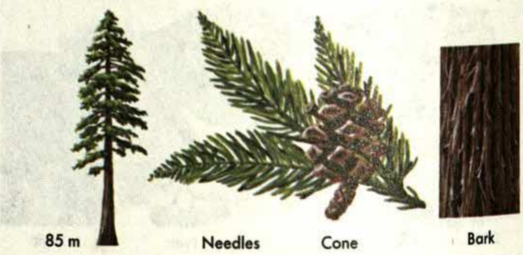
Larch, European *(Larix decidua).* Range—native to the Alps; widely planted.



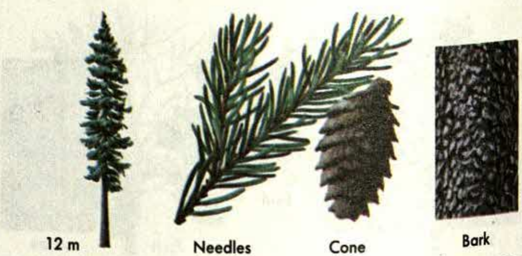
Pine, Scots *(Pinus sylvestris).* Range—native to northern Scotland; widely naturalized in southern England; planted in other countries.



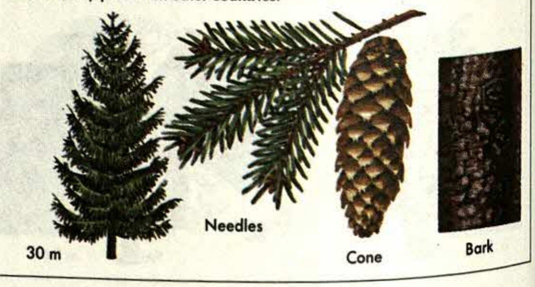
Redwood *(Sequoia sempervirens).* Range—U.S. Pacific Coast from southernmost Oregon to central California.



Spruce, Black *(Picea mariana).* Range—most of Alaska, U.S.A., and Canada and into Northeastern U.S.A.; widely planted in other countries.

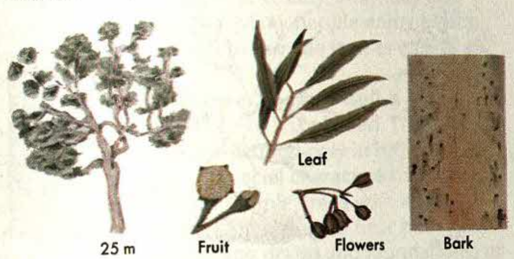


Spruce, Norway *(Picea abies).* Range—native to northern and central Europe; widely planted in other countries.

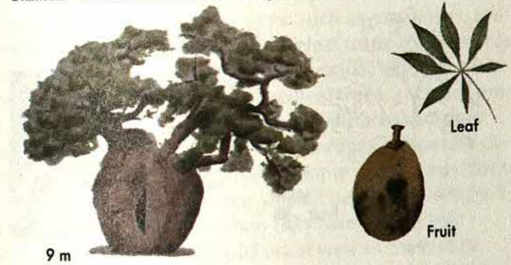


Trees of Australia and New Zealand

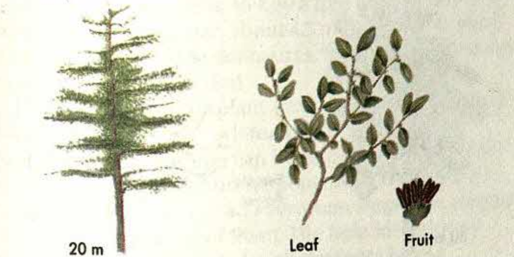
Angophora, Sydney red gum, or apple gum *(Angophora costata).* Range—Australia: Queensland, New South Wales, and northern Victoria.



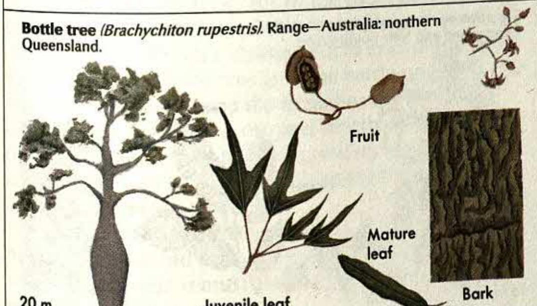
Baobab *(Adansonia gregorii).* Range—northern Western Australia. Diameter—10 metres at 1 metre above ground.



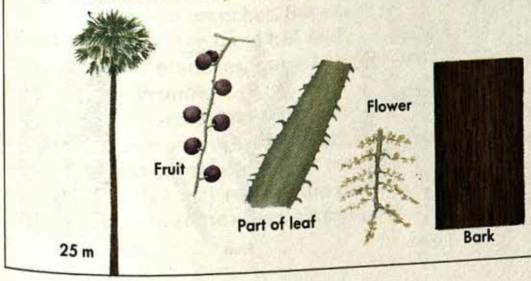
Beech, Southern *(Nothofagus truncata).* Range—New Zealand in lowland and pine forests of the North Island.



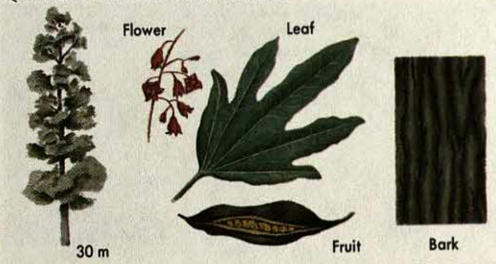
Bottle tree *(Brachychiton rupestris).* Range—Australia: northern Queensland.



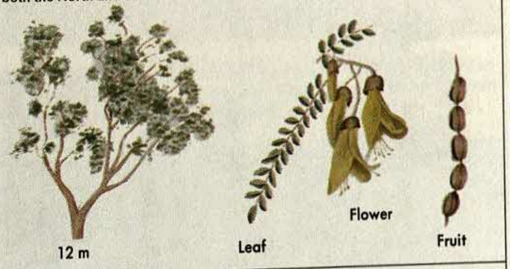
Cabbage tree palm *(Livistona australis).* Range—Australia: coastal scrub of Queensland and New South Wales.



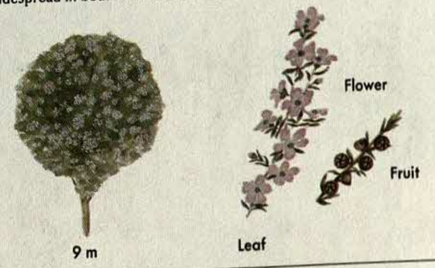
Flame tree, Illawarra *(Brachychiton acerifolius).* Range—Australia: Queensland and northern New South Wales.



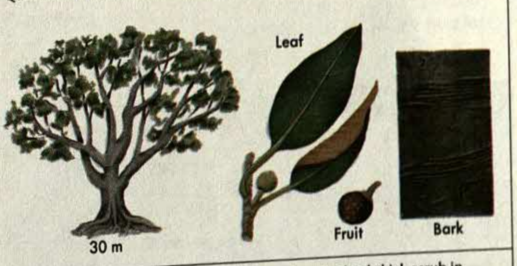
Kowhai *(Sophora microphylla).* Range—New Zealand: open forests in both the North and South islands.



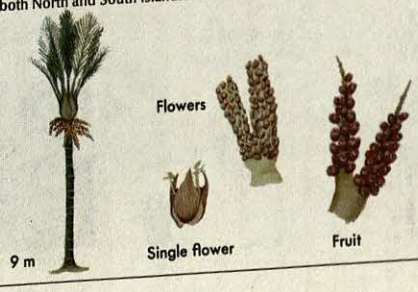
Manuka or teatree *(Leptospermum scoparium).* Range—New Zealand: widespread in both the North and South islands.



Moreton Bay fig *(Ficus macrophylla).* Range—Australia: coastal areas of Queensland and New South Wales.

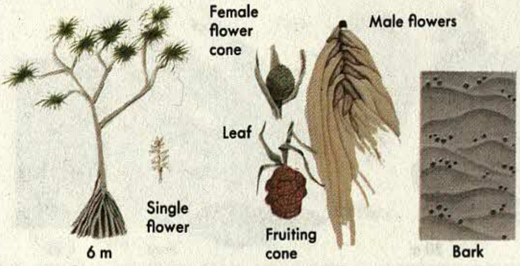


Nikau palm *(Rhopalostylis sapida).* Range—New Zealand: thick scrub in both North and South islands.

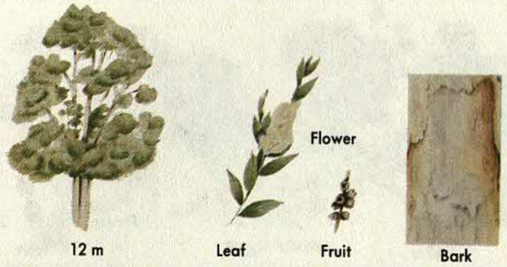


Familiar broadleaf and needleleaf trees—Trees of Australia and New Zealand

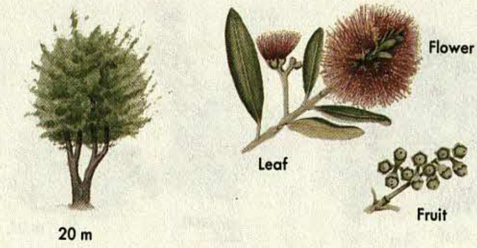
Pandanus or screw pine *(Pandanus pedunculatus).* Range—Australia: coastal Queensland and New South Wales.



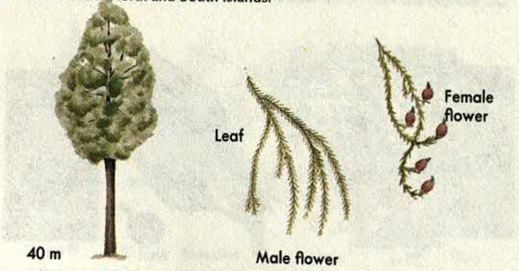
Paperbark, Prickly leaved *(Melaleuca stypheliodes).* Range—coastal swampy areas of Queensland and New South Wales.



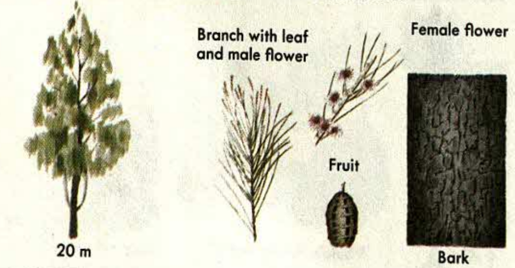
Pohutukawa or Christmas tree *(Metrosideros excelsa).* Range—New Zealand: coastal sands in forests.



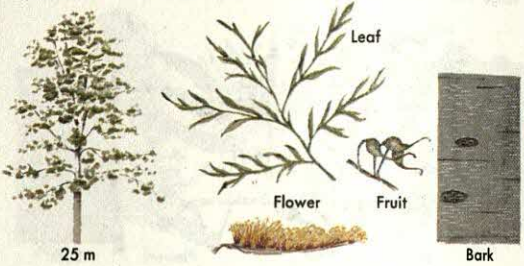
Rimu or red pine *(Dacrydium cupressinum).* Range—New Zealand: forests in both the North and South islands.



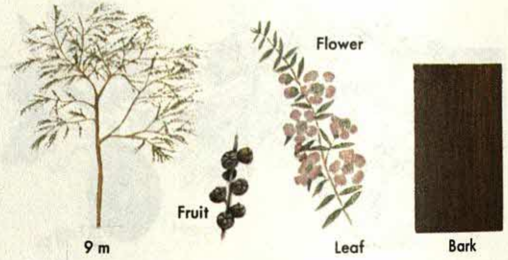
She oak, Horsetail *(Casuarina equisetifolia).* Range—New Zealand: coastal areas of Queensland and northern New South Wales.


Branch with leaf and male flower
Female flower
Fruit
20 m
Bark

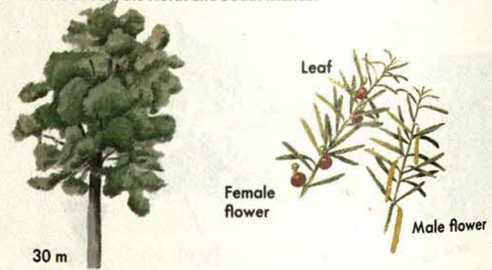
Silky oak *(Grevillea robusta).* Range—Australia: coastal brush forests of Queensland and New South Wales.



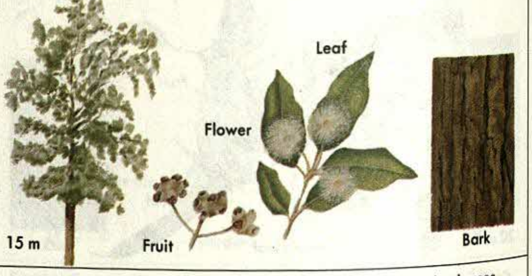
Teatree, Pink *(Leptospermum squarrosum).* Range—widespread throughout Australia.



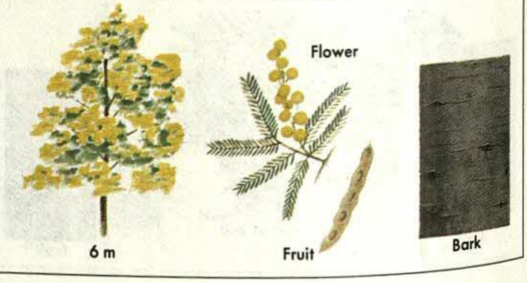
Totara *(Podocarpus totara).* Range—New Zealand: lowland and subalpine forests in both the North and South islands.



Turpentine *(Syncarpia glomulifera).* Range—Australia: coastal areas of Queensland and New South Wales.



Wattle, Cootamundra *(Acacia baileyana).* Range—Australia: inland areas of New South Wales and Victoria; widely naturalized.



Planting and caring for trees

Home-owners plant various kinds of trees on their property. They plant shade trees for protection from the sun and ornamental trees for beauty. They may also plant trees as windbreaks. Many people enjoy having fruit trees in their garden to provide fruit as well as shade and beauty.

Selecting the right tree. To grow well, a tree must be suited to the region where it is planted. Trees from faraway places should be planted only in regions with similar climates. A tree's special characteristics must also be considered. For example, trees with wide-spreading roots should not be planted near houses because the roots may damage drains and foundations, or block sewage pipes.

Trees with full, leafy crowns make the best shade trees. Trees with showy flowers, such as magnolias, are popular ornamental trees. Needleleaf trees are grown as ornamentals in many parts of the world. They also make good windbreaks. Various broadleaf trees, such as Lombardy poplars, are also planted as windbreaks. Apple and cherry trees are popular fruit trees in temperate climates. In warm climates, many people grow citrus trees.

Planting the tree. A tree should be planted where it will have enough room when fully grown. The soil should be fertile and should drain well so that water does not collect and drown the roots.

It takes much time and effort to grow a tree from seed. Most people prefer to buy a tree at a nursery. If a nursery tree is taller than about 4.5 metres or if its trunk is thicker than about 8 centimetres, special transplanting equipment may be needed.

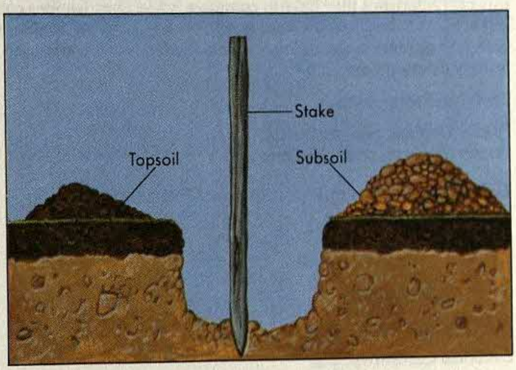
The best time to transplant a tree is when it is resting —that is, in the autumn, winter, or early spring. The roots of a deciduous tree can be dug up without a covering of soil. But they must be kept moist while out of the ground. The roots of an evergreen should be dug up with a ball of soil around them. The hole for any new tree should provide room for all the roots below ground level. Just before planting, any large roots should be cut off with a slanting cut to encourage new roots to develop. If the tree is of the hardwood type, the top should be cut off and the branches cut back to about one-fourth of their original length, to give the roots less work during the first growing season. A small tree may need to be supported by stakes to keep the wind from blowing it over.

Caring for the tree. A young tree should be kept moderately watered until it is well rooted, which usually takes about a year. It must also be fed with nutrients to promote healthy growth.

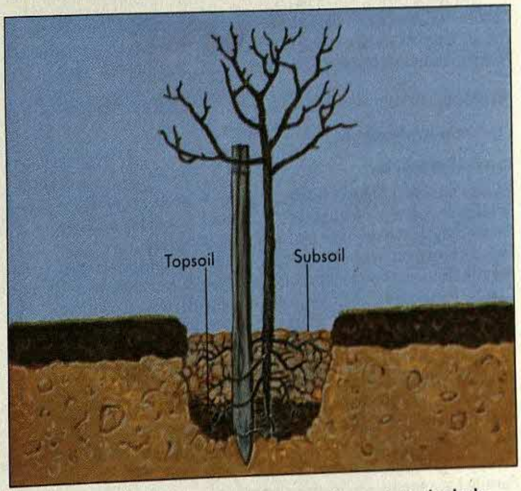
Pruning improves the shape of trees. Cutting off some of a young shade tree's lower buds will keep it from developing many low branches. But enough buds should be left so that the tree has a full, leafy crown. As the tree develops upper branches, more lower branches may be removed. See **Pruning.**

Insects and diseases may attack a tree. With normal care, it can overcome most minor attacks. But if a tree fails to develop as many leaves as usual or if the leaves look pale, the tree may require the professional care of a tree surgeon. In some areas, air pollution threatens the health of trees.

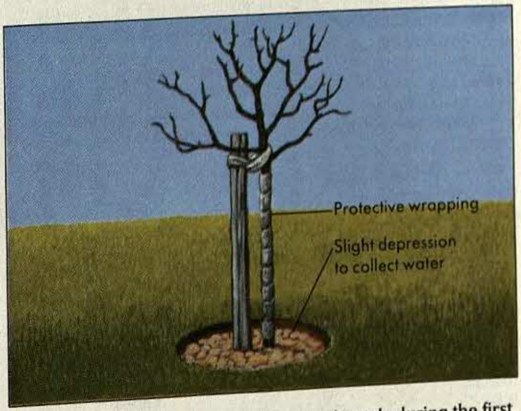
How to plant a tree



Digging the hole. Dig the hole big enough so all the roots can be spread out. Pile the topsoil and subsoil separately. A supporting stake, if needed, can be inserted at this time.



Planting the tree. Carefully spread out the roots in the hole and cover them with topsoil. Use the subsoil, which is less fertile, to fill the top part of the hole.


Protective wrapping
Slight depression to collect water

Caring for the tree. Water the tree moderately during the first year. The trunk may be wrapped in burlap or heavy paper for the first two years to protect it from sunburn and insects.

Scientific classification of trees

Trees belong to five *divisions* (groups) within the plant kingdom. Botanists further classify the plants in each division into classes, orders, and families. Plants are grouped according to the various characteristics they have in common. A few plant families consist largely of trees or shrubs, but some families have no trees at all. This table lists the families with the most species of trees or with one or more outstanding species. The families are arranged in the probable order of evolutionary development.

Division Pterophyta

Family Cyatheaceae—tree ferns
Family Dicksoniaceae—tree ferns

Gymnosperms (cone-bearing and related plants)

Division Cycadophyta

Family Cycadaceae—cycads

Division Ginkgophyta

Family Ginkgoaceae—ginkgo

Division Coniferophyta

Family Taxaceae—torreyas, yews
Family Podocarpaceae—podocarpuses
Family Pinaceae—cedar, Douglas firs, firs, hemlocks, larches, pines, spruces
Family Taxodiaceae—bald cypresses, giant sequoia, redwood
Family Cupressaceae—cypresses, junipers, western redcedar
Family Araucariaceae—Chile pine, kauri pine, paraná pine

Angiosperms (flowering, or fruit-bearing, plants)

Division Anthophyta

Class Dicotyledonae

Family Casuarinaceae—beefwoods, or Australian pines
Family Salicaceae—aspens, cottonwoods, poplars, willows
Family Myricaceae—wax myrtles, or bayberries
Family Juglandaceae—butternut, hickories, pecan, walnuts
Family Betulaceae—alders, birches, hazels, hornbeams
Family Fagaceae—beeches, chestnuts, oaks
Family Ulmaceae—elms, hackberry, planer tree, sugarberry
Family Moraceae—banyan, figs, mulberries, Osage orange
Family Proteaceae—macadamias, silky oak, silver tree
Family Santalaceae—sandalwoods
Family Phytolaccaceae—ombu
Family Magnoliaceae—magnolias, sweet bay, tulip tree
Family Annonaceae—cherimoya, pawpaw, ylang-ylang
Family Myristicaceae—nutmegs
Family Lauraceae—avocado, cinnamon, laurels, sassafras
Family Moringaceae—horseradish tree
Family Pittosporaceae—lemonwood, Victoria box
Family Hamamelidaceae—sweet gums, witch hazels
Family Platanaceae—sycamores, or plane trees
Family Rosaceae—almonds, apples, apricots, cherries, crab apples, hawthorns, loquat, medlar, mountain ashes, nectarine, peaches, pears, plums, quinces, serviceberries
Family Leguminosae (Fabaceae)—acacias, brazilwoods, carob, cassias, honey locusts, laburnums, locusts, logwood, mesquite, mimosa, paloverdes, poincianas, rain tree, tamarind
Family Zygophyllaceae—lignum vitae
Family Rutaceae—citruses, hop trees, prickly ashes
Family Simaroubaceae—ailanthus, bitter ashes, bitterbushes
Family Burseraceae—gumbo limbo, Java almond
Family Meliaceae—cedrelas, chinaberry, mahoganies
Family Euphorbiaceae—kukui, manchineel, rubber tree
Family Anacardiaceae—cashew, mango, pistachio, sumacs
Family Aquifoliaceae—hollies, mountain winterberry
Family Celastraceae—canotia, eastern wahoo, maytens
Family Aceraceae—boxelder, maples
Family Hippocastanaceae—buckeyes, horsechestnut
Family Sapindaceae—butterbough, litchi, soapberries
Family Rhamnaceae—buckthorns, jujubes, raisin tree
Family Tiliaceae—basswoods, or lindens
Family Bombacaceae—balsa, baobabs, kapok
Family Sterculiaceae—bottle tree, cacao, kola
Family Theaceae—loblolly bay, mountain stewartia, wild tea
Family Guttiferae—copey, mammee apple, mangosteens
Family Tamaricaceae—tamarisks
Family Caricaceae—papayas
Family Cactaceae—prickly pears, saguaro
Family Lythraceae—crape myrtles
Family Lecythidaceae—Brazil-nut, cannon-ball tree
Family Rhizophoraceae—dove tree, mangroves
Family Nyssaceae—tupelos
Family Combretaceae—Indian almond, oxhorn bucida
Family Myrtaceae—bay rum tree, bottlebrushes, clove tree, eucalyptuses, guavas, pimento, turpentine tree
Family Araliaceae—devil's walkingstick, lancewood
Family Cornaceae—cornelian cherry, dogwoods
Family Ericaceae—madroñas, mountain laurel, sorrel tree
Family Sapotaceae—bumelias, gutta-percha tree, sapodilla
Family Ebenaceae—ebonies, persimmons
Family Styracaceae—epaulette tree, silverbells, snowbells
Family Oleaceae—ashes, devilwood, fringe tree, olives
Family Loganiaceae—strychnine trees
Family Apocynaceae—devil tree, frangipani, yellow oleander
Family Boraginaceae—anaqua, geiger tree, strongbarks
Family Verbenaceae—Florida fiddlewood, teak
Family Bignoniaceae—calabash tree, catalpas, desert willow, jacaranda, royal paulownia, sausage tree
Family Rubiaceae—buttonbush, cinchonas, coffee trees
Family Caprifoliaceae—elders, viburnums

Class Monocotyledonae

Family Pandanaceae—pandanuses, or screw pines
Family Palmae—palmettos, palms
Family Liliaceae—aloes
Family Agavaceae—dragon tree, Joshua tree, Spanish bayonet
Family Musaceae—traveller's-tree

Study aids

Related articles in ***World Book*** include:

Broadleaf trees

Alder
Ash
Aspen
Beech
Birch
Bitternut
Boxelder
Catalpa
Chestnut
Cottonwood
Elm
Eucalyptus
Gum tree
Hackberry
Honey locust
Horsechestnut
Ironwood
Laurel
Linden
Live oak
Locust
Madroña
Maple
Myrtle
Oak
Osage orange
Poplar
Prickly ash
Sourwood
Sweet gum
Sycamore
Willow
Yellow-poplar

Needleleaf trees

Arborvitae
Bristlecone pine
Cedar
Cypress
Douglas fir
Fir
Hemlock
Juniper
Kauri
Larch
Pine
Redwood
Sequoia
Spruce
Yew

Fruit trees

Apple
Apricot
Avocado
Breadfruit
Cherimoya
Cherry
Citron
Crab apple
Date palm
Fig
Grapefruit
Guava
Kumquat
Lemon
Lime
Litchi
Loquat
Mango
Mangosteen
Mulberry
Nectarine
Olive
Orange
Papaya
Pawpaw
Peach
Pear
Persimmon
Plum
Pomegranate
Quince

Edible-nut trees

Almond
Brazil nut
Butternut
Cashew
Coconut palm
Hazel
Hickory
Pecan
Piñon
Pistachio nut
Walnut

Trees that yield special products

Balsa
Bayberry
Betel
Brazilwood
Cacao
Calabash
Camphor
Carob
Cinchona
Cinnamon
Clove
Coffee
Cork
Kapok
Kola nut
Mesquite
Nutmeg
Palm
Rubber
Sapodilla
Sassafras
Tallowtree
Witch hazel

Ornamental trees

Acacia
Box
Fringe tree
Holly
Judas tree
Laburnum
Magnolia
Mimosa
Myrtle
Peppertree
Poinciana
Rhododendron

Tropical trees

Baobab
Jacaranda
Mahogany
Mangrove
Rain tree
Tamarind
Teak

Unusual trees

Banyan tree
Bo tree
Bottle tree
Cannon-ball tree
Cycad
Ginkgo tree
Upas

Parts of trees

Bark
Bud
Cell
Flower
Fruit
Leaf
Root
Sap
Seed
Stem
Wood

Maps

See the plant life maps with the following articles:

Africa
Asia
Australia
Europe
North America
South America

Other related articles

Bonsai
Boxelder bug
Cellulose
Chlorophyll
Conifer
Conservation
Cotyledon
Ecology
Environmental pollution
Evergreen
Forest
Forest products
Grafting
Nursery
Plant
Pruning
Timber

Outline

I. The importance of trees
- A. Wood products
- B. Food products
- C. Other tree products
- D. Trees in conservation

II. Kinds of trees
- A. Broadleaf trees
- B. Needleleaf (or coniferous) trees
- C. Palm, pandanus, and lily trees
- D. Cycad trees
- E. Tree ferns
- F. Ginkgo trees
- G. Fossil trees

III. The parts of a tree
- A. Trunk and branches
- B. Leaves
- C. Roots
- D. Seeds

IV. How a tree grows
- A. How seeds sprout into trees
- B. How leaves make plant food
- C. How trees grow taller
- D. How trunks and branches grow thicker
- E. How trees reproduce

V. Trees around the world
- A. Broadleaf forests
- B. Tropical rainforests
- C. Needleleaf forests

VI. Planting and caring for trees
- A. Selecting the right tree
- B. Planting the tree
- C. Caring for the tree

VII. Scientific classification of trees

Questions

What is *sapwood*? *Heartwood*?
What is the main job of a tree's leaves?
In what climate do most needleleaf forests grow?
What do root hairs do?
How do forests spread?
How do *deciduous* trees differ from *evergreen* trees?
When is the best time of year to transplant a tree?
How do trees help conserve soil and water?
In what four ways do trees differ from all other plants?
How do trees grow taller?

Tree, Sir Herbert Beerbohm (1853-1917), an English actor and theatre manager, became famous for his magnificent Shakespearean productions at the Haymarket Theatre, in London, and later at Her Majesty's Theatre, also in London, which he founded in 1897. He composed a book of essays, *Thoughts and Afterthoughts* (1913). Tree was born in London. He was the half-brother of Sir Max Beerbohm, an author and caricaturist.

Tree farming. A tree farm is a privately owned area used to grow trees for profit. Tree farms range in size from 2 hectares to nearly 400,000 hectares. Forest organizations in many countries sponsor national tree-farm programmes.

Farmers have found that quick-growing trees can often be grown more profitably than *cash crops* (crops that are grown to be sold rather than consumed by the farmer), and they need less labour. In developing countries, many farmed trees are cut down for fuelwood and for poles. In the state of Gujarat in India, for example, a State Forestry Service scheme started in 1969 to distribute seedlings. The scheme became so popular that in 1983, villages and farmers received 200 million seedlings. In the Philippines, nearly 4,000 farmers grow trees for pulpwood.

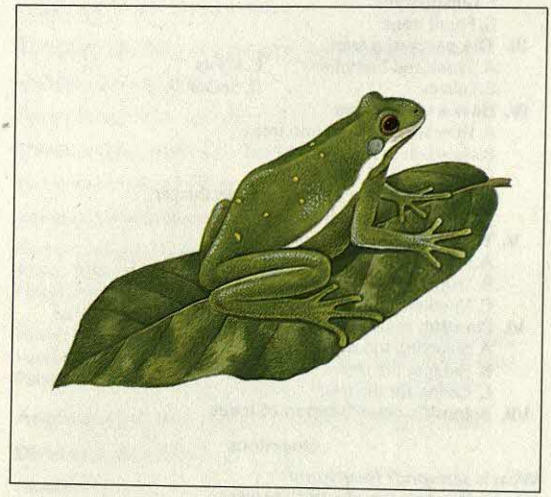
Many small farmers go in for tree farming. Usually, because the returns are delayed while the trees are growing, they need subsidies and loans. In some industrial countries, there are very large tree farms. The

United States has over 37,000 tree farms, covering a total of more than 32 million hectares.

See also **Forestry.**

Tree fern. See **Tree** (Tree ferns; picture: Tree ferns).

Tree frog is an *amphibian* (an animal that lives on land and in water) which spends much of its time in trees. There are several hundred *species* (kinds) of tree frogs. Most have sticky pads called *adhesive discs* on their toes, which help them to climb. Some have webbed feet, with large flaps of skin between the toes. This makes it possible for them to glide through the air between the branches. The body of a tree frog is flatter than the bodies of other frogs. Tree frogs range between about 1.5 and 12 centimetres long. They eat insects and other small animals.



The tree frog uses its sticky toes to climb trees. Most tree frogs can change colour to blend with their surroundings.

Tree frogs are divided into two groups: the largest group, the *true tree frogs,* has over 600 species. The true tree frogs are most common in South America. They are also found in Asia, Australia, New Guinea, North Africa, North America, and Europe (one species only). The other group of tree frogs, the *Old World tree frogs,* has about 180 species. The Old World tree frogs live in Africa, Southeast Asia, and Japan.

Most tree frogs are green or brown, but some have bright markings, such as reddish patches along the hind legs, which flash as the frog moves, and startle and confuse predators. Many tree frogs can change colour to blend with their surroundings.

Male tree frogs make a variety of sounds to attract females during the mating season. The males of some species of tree frogs make a loud call by puffing out their throats and forcing air over their vocal cords. Some male tree frogs form a large, noisy group known as a *chorus.* The South American *blacksmith tree frog* has a call like chiming metal; the *barking tree frog* of North America has a deep bark. The *green and gold bell frog* of Western Australia makes a sound like a saw going through wood.

Like other frogs, most tree frogs breed in water. A female may lay as many as a thousand eggs. Some species, however, such as the South American *Lutz's phyllomedusa,* lay their eggs on leaves overhanging a pond or river. When the tadpoles hatch, they drop from the leaf into the water below. Another species that lays its eggs in trees is *Wallace's flying frog.* This frog lives in the rainforests of Southeast Asia. It and other members of its family lay their eggs on leaves above water. The eggs are kept moist in a liquid which the male beats to a foam with his feet. When the tadpoles hatch, the foam becomes a small pool for them to swim in. The tadpoles of some species stay in this pool until they have become frogs. Others drop into the water after hatching. Some other species of tree frogs carry their eggs on their backs until the eggs hatch.

Scientific classification. True tree frogs make up the family Hylidae. True tree frogs include the blacksmith tree frog, *Hyla faber;* the barking tree frog, *H. gratiosa;* the green and gold bell frog, *Litoria cyclorhynchus;* and Lutz's phyllomedusa, *Phyllomedusa appendiculata.* Old World tree frogs belong to the family Rhacophoridae. Wallace's flying frog is *Rhacophorus nigropalmatus.*

See also **Amphibian; Frog.**

Tree of heaven. See **Ailanthus.**

Tree of life. See **Eden.**

Tree of wisdom. See **Bo tree.**

Tree shrew is a small, swift-moving mammal that lives in the forests of India, Southeast Asia, and southern China. Tree shrews look and act like small squirrels with long noses. They grow less than 20 centimetres long, not including their tails, and weigh less than 0.5 kilogram. Tree shrews dart about in trees and bushes and on the ground. Their food consists mostly of fruits, insects, and worms.

Zoologists disagree on what animals are the tree shrew's closest relatives. Some zoologists believe that tree shrews belong to the order of animals called *primates,* which includes monkeys and people. Tree shrews, like primates, have relatively large brains and eyes. Other zoologists classify tree shrews as members of the order of *insectivores,* which includes shrews and moles. Like insectivores, tree shrews have claws on all their fingers and toes. Primates have at least one nail on each foot. Still other zoologists put tree shrews in an order of their own. Experts do agree that the tree shrew is related to both primates and insectivores.

Scientific classification. Tree shrews belong to the tree shrew family, Tupaiidae. A common species is *Tupaia glis.*

The tree shrew is a mammal that resembles a small squirrel with a long nose. It lives in trees and bushes and on the ground.

Tree snake is any snake that lives in trees. Tree snakes have *prehensile* tails—that is, they are able to grasp objects with their tails. Examples of tree snakes are the *tree boa,* the *tree python,* and the *green viper* of the African forests. Tree snakes have specially adapted protective coloration. The *twig,* or *vine, snake* of the African forests is a dusty-brown, and resembles a dead branch almost exactly. Most tree snakes feed upon bats, birds, and lizards.

Scientific classification. Tree snakes belong to the families Boidae, Colubridae, Elapidae, and Viperidae.

See also **Snake.**

Tree squirrel. See **Squirrel.**

Tree surgery is the care of trees, chiefly by pruning, bracing, filling hollows, and removing decayed wood. Large operations may call for a tree surgeon who is an expert in these methods. Tree surgeons also treat cuts and wounds in trees. They spray trees with chemicals to protect against insects and diseases and they provide the proper fertilizers and moisture conditions for trees. Many communities employ tree surgeons to care for trees in parks and recreation areas.

Trees decay when fungi enter through wounds in the bark, and spread in the wood. An important part of tree surgery is to cover such cuts. Pruning cuts should be painted with shellac, grafting wax, or tree paint. The expert makes a pruning cut flat with the limb or tree trunk, and cuts off stubs of branches. The bark easily grows over the smooth cut. In cutting off large branches, the branch is first cut a distance away from the trunk, then the stub is removed. This method keeps the heavy limb from tearing bark from the tree when it falls.

Removing decayed wood is known as cavity work. It is rather expensive, and often not worth while unless the tree is large and beautiful or has sentimental or ornamental value. This type of surgery is most successful with sapwood, which is near the surface. Cavities in the heartwood are often large, and weaken the tree. The tree surgeon tries to remove all the decayed wood, and shape the hollow so it will not hold stagnant water. The cut part of the bark and *cambium* (a thin layer of growing tissue between the outer bark and the wood at the centre of a tree) is painted with shellac and the rest of the hollow is coated with a dressing like tar. The tree sometimes looks better if the hollow is filled, but filling does not strengthen the tree. It is often just as well to brace the tree with bolts or cables.

Some types of trees tend to split at the crotches of heavy limbs, especially in winter. The right way to prevent this type of split is to connect the limbs with a metal rod running through them and bolted at each end. The rod does not injure the tree, for it passes through a very small section of the living cambium. Cables or metal bands around a limb cut through the cambium as the limb grows, and strangle it.

See also **Pruning.**

Treecreeper. See **Creeper.**

Trefoil, meaning *three-leaved,* is the name generally applied to various plants having compound leaves with three leaflets, like the clover. It is specifically applied to the lotus group, which belongs to the pea family. Several members of this group are found in the temperate parts of the Northern Hemisphere. *Birdsfoot trefoil* is so called because it bears clusters of pods somewhat resembling a crow's foot. Other *species* (kinds) of trefoil include *marsh birdsfoot,* which is common in damp meadowland. See also **Birdsfoot trefoil.**

Scientific classification. The trefoils belong to the pea family, Leguminosae (Fabaceae). Birdsfoot trefoil is *Lotus corniculatus.* The marsh birdsfoot is *L. uliginosus.*

Trek, The Great. See **Boers.**

Trench foot is a diseased condition of the lower limbs and feet, caused by prolonged exposure to wet cold. The condition affected many soldiers fighting in the trenches during World War I (1914-1918). It resembles mild to moderate frostbite. Frostbite results from exposure to dry cold. Soldiers, outdoor workers, and hunters often suffer trench foot. It is treated like frostbite—by cleanliness, rest, and measures to restore the circulation.

See also **Frostbite.**

Trench mouth, also called *Vincent's infection,* is a disease which centres in the mouth and throat. It was given the name *trench mouth* during World War I (1914-1918), when thousands of soldiers got it while fighting in the trenches. Doctors are not sure what causes trench mouth, though they think it may be a bacterial infection. Poor oral hygiene and poor nutrition are frequently found in people with trench mouth and may contribute to the development of the disease. The disease does not seem to be contagious.

The first symptoms of trench mouth are mouth pains and bad breath. The disease most often occurs in the gums, which swell, bleed, and eventually are destroyed. Occasionally, it may affect the tonsils and other areas of the mouth and throat. A person who has the disease may find it difficult to chew or swallow food. Trench mouth is uncommon among people who have had all their teeth extracted.

Trenchard, Viscount (1873-1956), was a British military commander. He helped establish the Royal Air Force (RAF), the first air force independent of the army or navy in the world. His work as chief of the British air staff from 1919 to 1929 prepared the RAF for its vital role in World War II (1939-1945).

Hugh Montague Trenchard was born at Taunton, in Somerset, England, and entered the Army in 1893. He took an early interest in aviation, and was appointed an assistant commander of a military flying school in 1913. During World War I (1914-1918), he commanded the Royal Flying Corps in France. He served as commissioner of London's police from 1931 to 1935. He became a viscount in 1936.

Trent, Council of, was a series of conferences held by the Roman Catholic Church in Trent, Italy, between 1545 and 1563. The council attempted to define Catholic beliefs and to counteract Protestant teachings. The council also established many reforms in church practices. Its work became a major force in the Counter Reformation, the renewal movement in the Catholic Church during the 1500's and 1600's (see **Counter Reformation**). The doctrines issued by the council have greatly influenced the church ever since.

Pope Paul III called the council in 1542, and it opened on Dec. 13, 1545. The council met during three separate periods, and wars and religious disputes often interrupted its work. During the first period, from 1545 to 1547, the council declared that Scripture and tradition were equally valid sources of the Catholic faith. The council decreed that the church had the sole right to interpret Scripture. Tradition includes the writings of the apostles, the decrees of popes and councils, and the customs practised by Catholics throughout church history. The council also rejected Protestant views on salvation and sin.

During the second period, from 1551 to 1552, the council defined the nature of the seven sacraments. The council also reaffirmed the doctrine of *transubstantiation,* the belief that bread and wine are changed into the body and blood of Jesus Christ during Communion.

During its final period, from 1562 to 1563, the council defended the granting of *indulgences* (pardons from some of the penalty for sins). It also approved prayers to the saints and defined the sacrifice of the Mass and many other Catholic doctrines. The council passed such reforms as the establishment of seminaries to train priests and the requirement that each bishop live in his own area. Pope Pius IV confirmed all the council's decrees on Jan. 26, 1564, and they became part of Catholic doctrine.

Trent Affair was a naval incident in the first year of the American Civil War. It almost brought England into the conflict on the side of the South. In the autumn of 1861, two men representing the Confederacy, James M. Mason and John Slidell, set sail for Europe. Their mission was to enlist the aid of neutral France and England to the Southern cause. Since Northern ships were blockading Southern ports, they boarded a British ship, the *Trent,* in Havana, Cuba. Charles Wilkes, commander of the U.S.S. *San Jacinto,* stopped the British ship without orders to do so. He took Mason and Slidell prisoner and conveyed them to Boston, Massachusetts. This act violated the principle of freedom of the seas, because England was a neutral nation.

The British government demanded an apology and the immediate release of Mason and Slidell. To back up these demands, it ordered 8,000 troops to Canada. The United States government ordered the prisoners released, and made a formal apology. Mason and Slidell went on to Europe, but their mission failed.

Trenton (pop. 88,675; met. area pop. 325,824) is the capital of New Jersey, U.S.A., and an important manufacturing centre of the state. The city lies in west-central New Jersey, where the Assunpink Creek flows into the Delaware River.

In 1679, Quaker farmers led by Mahlon Stacy established the first permanent white settlement in what is now the Trenton area. In 1714, Mahlon Stacy, Jr., sold part of his father's property to William Trent, a merchant who later became chief justice of the New Jersey colony. The community was named *Trent's Town* in 1719, and its name later became *Trenton.*

Description. Trenton, the county seat of Mercer County, covers about 20 square kilometres. The golden dome of the State Capitol rises above the central area of the city. The New Jersey Cultural Center is near the capitol. It consists of the state library and museum, and a planetarium. The Battle Monument, 46 metres high, marks the site of a famous battle during the American Revolution (see **American Revolution**). Other landmarks include the 1719 home of William Trent and the Old Barracks, built in 1758 to house British troops. Rider College, Trenton State College, and Princeton University are near Trenton. Fort Dix, a large Army post, is also nearby.

Economy. The state government employs about 30 per cent of Trenton's workers. Major industries produce electrical goods, fabricated metal products, machinery, and rubber products. The printing and publishing industry is also important.

Government and history. Trenton has a mayor-council form of government. The voters elect the mayor and the seven city council members to four-year terms.

Delaware Indians lived in what is now the Trenton area before the British occupied New Jersey in the 1660's. During colonial times, Trenton became a major stopping place on the stagecoach line between New York City and Philadelphia. George Washington made his famous crossing of the Delaware River near Trenton in December 1776, during the American Revolution. Washington's troops defeated the Hessians in the battle that followed (see **Hessians**).

Trenton served as the nation's capital in November and December 1784. It became the capital of New Jersey in 1790 and received a city charter in 1792. During the 1800's, Trenton developed into an industrial and trade centre. An increase in river traffic, combined with the construction of railways, brought the city great industrial growth. Thousands of factory workers moved to Trenton, and the city's population rose by about 90,000 from 1880 to 1920. By 1920, Trenton was the leading U.S. pottery producer. It also ranked high in the production of rubber goods, steel, and wire cable.

After 1920, many of Trenton's residents and largest businesses began to move to the suburbs. Since 1950, the population of Trenton has declined. To reverse this decline, Trenton started a modernization programme. In 1974, the city barred traffic from two blocks of its main street and created a pedestrian mall called Trenton Commons. The state of New Jersey began an ambitious office building programme in Trenton, beginning with a law enforcement centre that opened in 1982. The construction of additional state buildings followed.

Trepang is the commercial name of the dried bodies of certain *species* (kinds) of marine animals called *sea cucumbers* (see **Sea cucumber**). Trepang is also called *bêche-de-mer.* It is used as food in the Far East. Sea cucumbers have soft, wormlike bodies. They range from a few centimetres to about 60 centimetres in length. To prepare the edible species, the inner parts are removed and the bodies are boiled. Then they are soaked in fresh water and smoked or dried in the sun. This produces a rubberlike substance used to thicken and flavour soups.

The chief centre of the trepang industry is Ujung Pandang, a seaport of Sulawesi, in Indonesia. California, U.S.A., also has a trepang industry.

Trephining is a surgical operation that involves cutting out a small, circular piece of the skull. The operation is done with an instrument called a *trephine.* Trephining is used in the treatment of certain head injuries. It relieves pressure on the brain caused by bleeding between the skull and the brain. Trephining is also used to remove blood clots and to gain entry to the brain for certain surgical procedures.

Trephining is the earliest-known surgical treatment. Evidence of trephining has been found in human skulls that date from prehistoric times. Anthropologists have found trephined skulls throughout much of the world. Ancient peoples probably used trephining to release spirits that were believed responsible for headaches, mental disorders, and epilepsy. Some ancient warriors trephined the skulls of people they killed in battle. The warriors wore the piece of bone as a trophy or to ward off evil spirits. The Inca and other South American Indians practised trephining.

See also **Medicine** (History; picture: Trephining).

Trespass, in law, is most commonly known as the unlawful entrance upon the property of another. The term also means injury to the person or personal property of another. "No trespassing" signs are seen commonly where owners of farms, private estates, and club grounds desire to protect their property from intrusion. Failure to regard such notices is an unlawful act but not a crime.

False imprisonment and assault and battery are examples of trespass to the person. Trespass makes a person liable to a civil law suit for damages.

See also **Assault and battery; Tort.**

Trestle, in engineering, is a structure used to support a roadway over a valley or crossroads. A wooden trestle, made of *bents* (tall posts connected by ties and braces), usually costs less to build than a bridge. In carpentry, a trestle is a beam on legs. It is used to support work. Some tables and drawing boards are supported by a frame called a trestle.

Trevelyan, George Macaulay (1876-1962), was a famous British historian. His two best-known books are *History of England* (1926) and *English Social History* (1942). Trevelyan's vivid descriptions of social life and his dramatic and imaginative writing style appealed to the general public. In his writings, he promoted the views of the Whig Party, which was important in British politics from the 1600's to the mid-1800's, and of its successor, the Liberal Party. Whigs and Liberals believed the common people had a more positive effect on history than did royalty and that democratic government would bring about steady social progress.

Trevelyan was born near Stratford-upon-Avon, England. His father was Sir George Otto Trevelyan, a politician and historian. The younger Trevelyan first won wide praise for a three-volume biography of the Italian military hero Giuseppe Garibaldi, published between 1907 and 1911. Trevelyan taught modern history at Cambridge University from 1927 until 1940, when he became master of Trinity College. He also wrote *England Under Queen Anne* (1930 to 1934) and *The English Revolution, 1688-1689* (1938).

Trevino, Lee (1939-), is an American golfer. Few people had heard of Trevino before he won the United States Open in 1968. But he soon gained fame as one of the most colourful and popular figures in sport. During tournaments, Trevino often joked with his many followers, who became known as "Lee's fleas."

In 1971, Trevino accomplished one of the most remarkable winning streaks in golfing history. Within 16 weeks that year, he won five tournaments and finished among the top five money winners in four others. No other golfer had ever won the U.S., Canadian, and British opens during the same year. Trevino also won the Professional Golfers' Association (PGA) tournament in 1974 and 1984. Lee Buck Trevino was born in Dallas, Texas, U.S.A.

Trevithick, Richard (1771-1833), was an English inventor and engineer. He contributed to the development of the steam locomotive.

Trevithick was born in Cornwall, a tin-mining region in southwestern England. As he grew up, he became interested in the steam engines that pumped water from the mines. By the early 1800's, he had developed a new engine that was soon used in most of the local mines. This high-pressure engine was the model for most later steam engines.

In 1801, Trevithick designed and built a steam-powered carriage that ran on the road. In 1804, he built the first steam locomotive to run on rails. In 1808, he exhibited a large locomotive in London. None of his locomotives were financially successful, because they were too heavy for the roads and railways of his time. But Trevithick did prove that steam-powered locomotives could be built.

See also **Locomotive** (picture); **Railway** (History).

Trevor, William (1928-), an Irish writer, first won recognition for his novel *The Old Boys* (1964). Trevor's other novels include *The Children of Dynmouth* (1976), *Fools of Fortune* (1983), and *Felicia's Journey* (1994), all of which won the British Whitbread Novel award. *Felicia's Journey,* about a serial killer, was a controversial choice for an award because of the violent nature of the book.

Some of Trevor's short stories, "The Ballroom of Romance" (1972) and "Lovers of their Time" (1978), for example, have been televised. Many of Trevor's works are set in his native Ireland and show an insight into the lives and characters of ordinary people, especially the elderly, the lonely, and the unsuccessful.

Mohamed Ansar, Camera Press

William Trevor

Trevor was born at Michelstown, County Cork. He was educated at Trinity College, Dublin.

Trial is a method of settling disputes verbally in a court of law. In most cases, the people on each side of the dispute use a lawyer to represent their views, present evidence, and question witnesses. Many trials are jury trials. In the other trials, the defendant is tried by a judge or a panel of judges instead of a jury.

There are two types of trials, *civil trials* and *criminal trials.* Civil trials settle noncriminal matters, such as contracts, ownership of property, and payment for personal injury. The jury decides who is at fault and how much money must be paid in damages. In a criminal trial, a jury is often used to decide the legal guilt or innocence of a person accused of a crime.

A jury trial begins with the selection of the jurors. Then the *prosecuting counsel,* who argues the case against the defendant in a criminal trial, and the *defence counsel* make their opening statements to the jury. In a civil trial, one side is represented by the lawyer for the *plaintiff* (the person who began the legal proceedings).

The other side is represented by the defence lawyer. In their opening statements to the jury, the lawyers for both sides declare what they intend to prove during the trial.

Presenting evidence. Each lawyer presents evidence to support his or her side of the case. The evidence may include documents, such as letters or receipts; or objects, such as weapons or clothing. In most cases, the evidence consists of testimony given by witnesses who are sworn to tell the truth. Witnesses generally give their evidence in response to questions asked by a lawyer. Then the opposing lawyer cross-examines the witnesses and attempts to find mistakes in their evidence. A witness who is suspected of deliberately lying may be accused of *perjury*.

The admission of evidence in a trial is governed by certain rules. In general, information is admitted as evidence only if it is (1) relevant, (2) material, and (3) firsthand. Relevant information is related to a question in the case and helps answer the question. Material information helps settle the main issue of the trial. Firsthand information comes from the witness's personal knowledge, not from hearsay.

Following the testimony and cross-examination, the lawyers for each side summarize the case. Then, in a *summing up to the jury,* the judge gives instructions concerning the laws that apply to the case.

The judge in each trial decides what evidence will be admitted. In a jury trial, the judge will make a ruling, in the absence of the jury, as to the admissibility of evidence. If inadmissible evidence is heard, it may be grounds for an appeal against the final decision. The judge may also hold in *contempt of court* any person who shows disrespect for the court by disrupting a trial. Such a person may be fined or imprisoned, or both.

Reaching a verdict. The jury is taken to a private room to discuss the case and reach a verdict. At this stage, jurors are not allowed to communicate with anyone else, except through the judge. If they do not reach a verdict by the end of the day, they may be kept together in a hotel overnight and brought back to court the next day.

In a criminal trial, the prosecuting counsel tries to prove the defendant's guilt "beyond a reasonable doubt," which is the standard required by law. If the jurors do not feel the prosecuting counsel has done so, they must *acquit* the defendant—that is, find him or her not guilty. If the jury finds the defendant guilty, the judge will sentence the defendant. In a civil trial, the lawyer for the plaintiff must prove the plaintiff's claim on a balance of probabilities.

A *hung jury* is one in which the required number of jurors cannot agree on a verdict. A new trial—with new jurors—is then held.

The defendant's rights. The constitutional law of most democratic countries guarantees accused people many rights concerning a fair trial. For example, the right to jury trial is specified in many cases, and the right known as *due process* provides that the trial will be conducted according to the law. Other safeguards include the prevention from being held in custody for more than a specified time without a hearing, the right to a public trial, and the right to legal advice and representation in court.

Certain safeguards are sometimes known as the rules of natural justice. The main rules of natural justice are that no person shall be a judge in his own cause and that no person shall be condemned unheard. The rule that no one can be a judge in his own cause means that any judge or member of a jury who has a personal interest in a case must withdraw and not take part in the decision. The rule that no one may be condemned unheard means that a person must be given prior warning of proceedings against him and must be allowed to defend himself. So in a criminal case, the defendant must be properly charged with an offence according to the law and be given time to prepare his defence. Similarly, in a civil case, the defendant must be given full details of the allegations against him and the evidence to be called.

Appeals. A defendant who has been tried and convicted in a criminal trial can use his or her right to *appeal.* In a civil case, the losing side sometimes has a right of appeal. In an appeal, the appellant asks that the case be retried by a higher court called an *appellate court.* Some cases have an automatic right of appeal. In others, the defendant must show some reason for retrying the case, such as the discovery of new evidence or the importance of deciding a point of law by a higher court. In some cases, the appellate court may refuse to hear the appeal. In other cases, the appeal court may send the case back to the original court for a retrial. An appellate court does not use a jury, but there is usually more than one judge. Lawyers present the appeal by oral arguments.

Settlements out of court. The English legal system is based on the belief that a person is considered innocent until proven guilty. But only a small percentage of legal disputes are settled by a trial. The defendant pleads guilty in many cases, and so no trial is needed. In civil proceedings, cases are often settled *out of court,* either before the trial begins or during the trial once some of the evidence has been heard. Sometimes, where damages are claimed, the defendant may pay a sum of money into court, which the plaintiff may accept instead of pursuing the action.

Costs. In all cases, whether criminal or civil, the last thing the judge has to decide is who is to pay the costs of the case. In many cases, the losing side pays, but there are exceptions. Rules of practice determine how the costs of the court are worked out and appeals may be made against the assessment or *taxation* of costs.

History. The Saxons, who lived in England during the Middle Ages, gave accused people a *trial by ordeal* rather than by jury. The defendant was perhaps required to hold a piece of red-hot iron or was deliberately injured in some other way. The Saxons believed that God would heal the accused person's wounds within three days if he or she was innocent. After the Norman Conquest in 1066, two persons fought if they disagreed about a matter. They believed that God would grant victory to the one who was right.

The present trial system used in England and in countries whose legal system is based on that of England developed from English *common law* and *equity.* Common law is a group of rulings made by judges on the basis of community customs and previous court decisions. Equity is a set of standards based on broad principles of justice. English colonists took their legal system with them to Australia, New Zealand, North America, and all the Commonwealth countries.

Related articles in *World Book* include:

Appeal
Contempt
Court
Crime
Evidence
Judge
Jury
Law
Perjury
Plea bargaining
Sentence
Trial by combat
Witness

Trial by combat, also called *trial by battle* or *wager of battle,* was a way of settling legal disputes in the Middle Ages. Noblemen used it for many years. Trial by combat differed from a fight or duel because people believed that God would interfere and help the righteous person win. The general procedure was for the accused to fight the accuser. Noblemen sometimes appointed champions to do their fighting for them. Women and priests were generally represented by others. Trial by combat was introduced into England by William the Conqueror. Trial by jury gradually took its place.

Trial by ordeal was another way of determining a person's innocence or guilt during the Middle Ages. In trial by ordeal, a person was subjected to various forms of physical torture. If the injuries healed within three days, the person was considered innocent.

See also **Divination.**

Triangle, in plane geometry, is an enclosed figure that has three line segments for sides. The sides meet at three points called *vertices,* and each vertex forms an *angle* with two of the sides. The sum of the three angles of a triangle is always 180°. A triangle is a type of polygon (see **Polygon**).

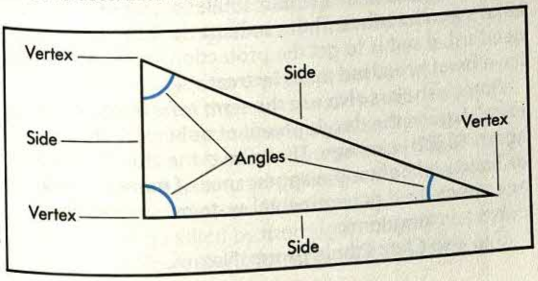
Kinds of triangles. Triangles can be classified according to the relationships of their sides. A *scalene* triangle is a figure with three unequal sides. An *isosceles* triangle has at least two equal sides. A triangle with all three sides of equal length is called an *equilateral* triangle. Therefore, every equilateral triangle is also an isosceles triangle, but not every isosceles triangle is an equilateral triangle.

Triangles are also classified by their angles. A triangle in which every angle is smaller than 90° is an *acute* triangle. An *obtuse* triangle has one angle larger than 90°. A *right-angled* triangle has one right—that is, 90°—angle. No triangle can have more than one obtuse angle or one right angle.

Properties and relationships of triangles. The parts of a triangle have many interesting characteristics and relationships. Sometimes a useful relationship between two or more triangles can also be established. Some of the most notable of these properties and relationships are discussed below.

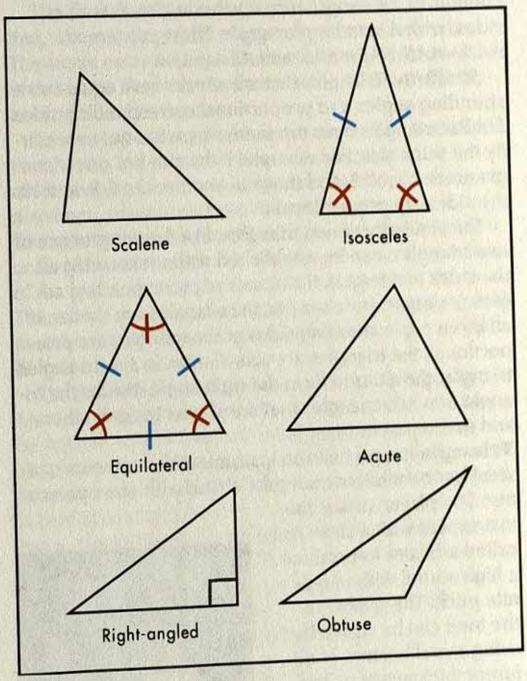
The parts of a triangle

A triangle is a plane figure that has three sides and three angles. The line segments that form the sides meet at three points called *vertices.* Each vertex forms an angle with two of the sides.



Kinds of triangles

Triangles can be classified by their angles or by the relationships of their sides. In the diagrams below, the blue lines indicate equal sides of a triangle. The red symbols mark equal angles. The grey box marks a *right angle*—that is, an angle of 90°.



Perimeter and area. The *perimeter* of a triangle is the sum of the lengths of its sides. To find the *area* of a triangle, we must know the *altitude,* or *height,* which is the perpendicular distance from a vertex to the opposite side, or *base.* The area is calculated by multiplying the base by the altitude and then dividing by 2. Even if the perimeters of several triangles are the same, the areas of those triangles may differ.

Right-angled triangles and Pythagoras' theorem. The sides of a right-angled triangle have a special relationship to each other. This relationship is expressed in a mathematical statement called *Pythagoras' theorem* (see **Pythagoras' theorem**). This theorem was known in ancient civilizations, but it is credited to Pythagoras, a Greek philosopher and mathematician. According to Pythagoras' theorem, a triangle is a right-angled triangle if and only if the sum of the squares of the two shorter sides equals the square of the longest side, called the *hypotenuse.* This statement can be written as a formula: $a^2 + b^2 = c^2$. For example, if the sides of a triangle are 6, 8, and 10, the triangle is a right-angled triangle because $36 + 64 = 100$. The formula enables us to find the length of any side of a right-angled triangle if we know the lengths of the other two sides.

Congruence. Two triangles are *congruent*—that is, they have exactly the same size and shape—if all their corresponding sides and angles are equal. Mathematicians have formulated specific sets of conditions for determining congruence. For example, two triangles are congruent if the sides of one equal the corresponding sides of the other. Using S to represent *side,* this statement can be abbreviated as $SSS=SSS$. Other sets of conditions for congruency involve angles as well as sides, with A standing for *angle.* These sets are $AAS=AAS$, $SAS=SAS$, and $ASA=ASA$.

Similarity. Triangles that are *similar* have equal corresponding angles and proportional corresponding sides. Similar triangles have the same shape but not necessarily the same size. For example, if the sides of one triangle are 3, 4, and 5, and those of another are 6, 8, and 10, the sides are proportional.

The similarity of two triangles, like the congruence of two triangles, can be established without knowing all the sides and angles. If two sets of corresponding angles are equal, for example, the triangles are similar. If all three corresponding sides of the triangles are proportional, the triangles are also similar. In a right-angled triangle, the altitude from the right angle divides the triangle into two triangles that are similar to each other and to the parent triangle.

Triangle is a percussion instrument that consists of a steel bar bent into a triangular shape with one open corner. The player strikes the instrument with a short rod called a *beater* to produce a high sound with indefinite pitch. The quality of the tone can be varied by using metal beaters of different thicknesses or by using a wooden, rather than a metal, beater. A musician usually holds the triangle in one hand by a clip at the top and grasps the beater in the other hand. But the triangle can also be clipped to a stand and played with two beaters, one in each hand.

A triangle is a steel percussion instrument shaped like a triangle and open at one corner. A player hits it with a rod.

Trianon, Treaty of, was signed by Hungary and the Western Allies after World War I (1914-1918). The treaty was signed in the gallery of the Grand Trianon, a palace at Versailles, in France, on June 4, 1920. It severely punished Hungary for its part in the war. The United States, which signed the treaty but never ratified it, made a separate peace with Hungary in 1921.

The Trianon treaty reduced Hungarian territory from 325,326 square kilometres to 91,126 square kilometres. The country's population dropped from about 21 million to about 8 million, and it was left with no seaports. Hungary's bitter complaints against the treaty brought few results.

The Treaty of Trianon forced Hungary to recognize the new boundaries of Austria, Czechoslovakia, Romania, and what became Yugoslavia. Hungary had to give up its claims to the port of Fiume, and was allowed to keep an army of only 35,000 men. All Hungarian merchant ships had to be surrendered to the Allies. Hungary lost Slovakia, Transylvania, and Croatia to neighbouring countries. About 3 million Magyars were separated from their fellow Hungarians.

Triassic Period. See Earth (table: Outline of earth history).

Tribe is a term used to describe certain human social groups. Some scholars dislike the term because it lacks a precise meaning and has been applied to many widely different groups. In addition, many of the peoples called tribes consider the term offensive or inaccurate. Most prefer more neutral terms such as *ethnic group, nation,* or *people.*

The first use of the word *tribe* in English referred to the Hebrews. Until about 1000 B.C., the Hebrews were loosely organized into 12 groups, each of which traced its descent to one of the 12 sons of Jacob. These groups were called the 12 Tribes of Israel. The term *tribe* was soon extended to mean any group of families who traced themselves to a common ancestor.

Beginning in the 1400's, many European nations established colonies in Africa, Asia, and North and South America. The Europeans often described the peoples of those areas as tribes, though the groups varied greatly in their economic, political, and social organization. Some of the so-called tribes consisted of unrelated groups. Others were more accurately called nations. Most Europeans regarded the colonized peoples, whose technology was less advanced than theirs, as primitive. In time, the word *tribe* acquired the broad meaning of "primitive group."

Anthropologists have added other characteristics to the definition of tribe, though different scholars emphasize different features. Many define a tribe as a group with a sense of shared identity and ties of ancestry, customs, language, and territory. Others believe a tribe also must have some form of political organization, such as a means of making decisions for the group and of settling disputes between its members. Some scientists regard only groups without a written language as tribes. Others define a tribal economy as one that operates to produce only enough food and other necessities for members of the group, with little or no surplus. Almost no groups have all these characteristics, though the Tiv of Nigeria and the Zuñi Indians of the United States come close.

Today, many black Africans and other peoples consider the word *tribe* as insulting because they believe it implies that they are primitive. Other so-called tribes consider the term inaccurate because they regard themselves as separate groups. For example, the Yoruba, Nigeria's largest ethnic group, are sometimes called a tribe. But they include the Egba, the Ife, the Oyo, and other peoples, each with their own culture and political organization.

On the other hand, several American Indian groups have struggled since the mid-1900's to gain or regain legal status as tribes. These Indians declare that they need tribal status to get the protection and benefits that have been promised them by treaties.

Some scholars also use the term *tribe* to refer to an early stage in the development of political systems, about 10,000 years ago. The tribe came after the family or band and before the appearance of more centralized and specialized governmental systems, such as chiefdoms and kingdoms.

See also **Clan; Ethnic group; Nation.**

Tribunal is a court of justice appointed to examine special evidence or appeals. Tribunals are formed to *arbitrate* (judge) in industrial disputes, investigate accusations made against a government, and to consider appeals made by individuals against the state. Many professional organizations maintain tribunals that exercise control over members of the profession. See also **Arbitration.**

Tribune was an official in ancient Rome. There were two kinds of tribunes, *military tribunes* and *tribunes of the people.*

The first military tribunes were leaders of the soldiers that the various Roman tribes furnished to serve in the army of the republic. There were six tribunes to each *legion* (group of soldiers). They ranked next after the commander in chief. The early tribunes were appointed by *consuls* (chief government officials). Later, the people elected them. During the Roman Empire period, military tribunes lost much of their importance.

Tribunes of the people were officials elected to protect the rights of *plebeians* (commoners). According to one account, the plebeians left Rome in 494 B.C. and refused to return until they were allowed to elect their own defenders. Historians believe that at first there were only two tribunes. Later there were four or five, and then 10. They held office for a term of one year, but could be reelected. The tribunes could defend citizens against unfair acts by officials. In the Senate, they could veto bills. In their own assembly, they could introduce *plebiscites* (resolutions made by the plebeians). They could not be imprisoned. Tribunes became the most powerful civil officers in the state, although their powers did not extend beyond the city limits of Rome. Largely because of the work of the tribunes, the plebeians gradually took over many of the political rights that had once belonged only to *patricians* (aristocrats). In 23 B.C., Emperor Augustus received the powers of a tribune. These powers enabled Roman emperors to add civil authority to their military power.

In the A.D. 1300's, an Italian patriot named Cola di Rienzi took the title of tribune when he led the common people in their fight for freedom from the nobles. Those who defend the common people are often called tribunes. See **Rienzi, Cola di.**

See also **Legion; Rome, Ancient** (Government).

Tributary. See **River** (The source of a river).

Triceps. See **Arm.**

Trichina is a small roundworm that causes the disease *trichinosis.* The worm is a *parasite.* That is, it lives in and feeds on other animals.

The trichina infects human beings and other animals, especially pigs, bears, and rats. Most infections of trichinosis result from eating infected pork that has not been cooked enough. Trichinosis in pigs, bears, and rats usually results from eating infected meat and infected refuse.

The *larvae* (early form of the worms) live in microscopic *cysts* (sacs) in the muscles of animals they infect. They usually live in the animal's chest and neck muscles. If an animal infected by the larvae is allowed to live, the cysts eventually harden and the larvae die. But sometimes infected animals are killed for meat. In such cases, the larvae can be killed by thoroughly cooking or freezing the meat. However, if the larvae are not killed and the meat is eaten, the larvae are freed from the cysts during digestion. The larvae attach themselves to the intestine of the person who eats the meat. They become adult worms in about 3 or 4 days. The largest are only about 6 millimetres long.

The adult females burrow into the wall of the intestine, where they produce large numbers of active larvae. The larvae enter the blood and are carried to many parts of the body. They eventually leave the blood and form new cysts in the muscles.

Some people carry trichina worms in their bodies for many years and never have severe symptoms. But in other people, the worms irritate the intestine and cause diarrhoea, nausea, and vomiting. When they pass through the blood, fever, headache, and muscular pain occur. After they reach the muscles, they cause swelling of the face and other parts and bleeding under the skin. The worms may form their cysts in the *diaphragm* (chief muscle used for breathing) and make breathing painful. The disease is seldom fatal.

The prevention of trichinosis involves several steps. Meat scraps may carry trichina worms, so they should be cooked before they are fed to pigs. Meat packers should freeze pork to kill any worms the pork may carry. Finally, cooks should be sure the central section of pork is held at a temperature of at least 58° C for 5 minutes or more. The number of trichinosis infections is low in places where these preventive measures are followed.

Scientific classification. Trichina belongs to the phylum Nematoda, family Trichinellidae. It is *Trichinella spiralis.*

See also **Nematoda; Roundworm.**

Trichinosis. See **Trichina.**

Trichoptera. See **Insect** (table).

Tricolour is the French national flag. It has equal red, white, and blue vertical sections. The three colours were first used as a French emblem on July 17, 1789, during the French Revolution. King Louis XVI had come to Paris after the fall of the Bastille. He put a tricolour knot of ribbons on his hat as a patriotic gesture. Red and blue were the official colours of Paris, and white was the colour of the royal family. After the royal family was restored to power in 1814, it rejected the tricolour. But the tricolour again became the French national flag in 1830. See **Flag** (picture).

Trier (pop. 93,472) is the oldest city in Germany. It lies on the Moselle River in the state of Rhineland-Palatinate (see **Germany** [political map]). Trier is the centre and market area of a famous wine district. The city makes leather goods, steel products, and textiles. It is also an important railway junction.

Trier was founded by the Romans, probably around 15 B.C. It was named after the Treveri, a people of ancient Gaul. A number of Roman monuments, including an amphitheatre, baths, and the celebrated *Porta Nigra* (fortified north gate), stand in the city. Trier's cathedral dates from Roman times, and houses a garment believed to be the seamless coat of Jesus Christ. The city has been an important centre of Roman Catholic tradition since the Middle Ages. It has many beautiful examples of church architecture, including the St. Simeon monastery and the St. Paulin baroque church. Trier came under French control in 1806 and was awarded to Prussia by the Congress of Vienna in 1814-1815. The French occupied Trier after World War I ended in 1918.

Trieste (pop. 231,100) is a city in northeastern Italy. Several nations use Trieste's free port, which does not tax imported goods. The city produces clothing, iron and steel, machinery, and paint. Trieste lies at the northern end of the Adriatic Sea. For location, see **Italy** (political map).

Trieste was a Roman colony from the 100's B.C. to about A.D. 500. Austria gained control of the area in the late 1300's. Treaties following World War I (1914-1918) gave Trieste to Italy. In 1946, after World War II, the United Nations took over Trieste and an area to the south of the city. In 1954, Trieste came under Italian control. Yugoslavia administered the area to the south. Italy took formal possession of the city in 1975 and the southern land became part of what is now Slovenia.

Trieste. See **Exploration** (Deep-sea exploration; picture: The bathyscaph *Trieste*).

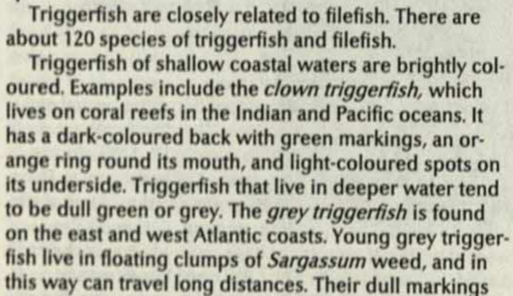
Triggerfish is a type of fish that lives in warm and tropical seas. Most triggerfish are less than 45 centimetres long and have a roundish body with flattened sides.

The first three spines of a triggerfish's dorsal fin are specialized. The fish uses these spines to enlarge its body when threatened. The first spine is long and strong. It can be locked in place by the second, smaller spine, which lifts up and acts as a "trigger." When frightened, the fish hides in a crack or crevice and locks its spine. The fish then cannot be removed by predators. It can return to its normal size by releasing its second spine.

Triggerfish are closely related to filefish. There are about 120 species of triggerfish and filefish.

Triggerfish of shallow coastal waters are brightly coloured. Examples include the *clown triggerfish,* which lives on coral reefs in the Indian and Pacific oceans. It has a dark-coloured back with green markings, an orange ring round its mouth, and light-coloured spots on its underside. Triggerfish that live in deeper water tend to be dull green or grey. The *grey triggerfish* is found on the east and west Atlantic coasts. Young grey triggerfish live in floating clumps of *Sargassum* weed, and in this way can travel long distances. Their dull markings help them remain concealed in the weed. Some triggerfish can make loud noises. The *black-barred triggerfish* of the Indian and Pacific oceans achieves this by rubbing together bones at the base of its pectoral fin. The sound produced is *amplified* (increased) by vibrations of the fish's swim-bladder.

Triggerfish have teeth similar to those of rats. They use these to crack open shellfish, upon which they feed.



The triggerfish lives in warm coastal waters. Some species have colourful markings.

Scientific classification. Triggerfish and filefish belong to the family Balistidae. The clown triggerfish is *Balistoides conspicillum.* The grey triggerfish is *Balistes carolinensis.* The black-barred triggerfish is *Rhinecanthus aculeatus.*

See also **Fish** (picture: Fish of coral reefs).

Triglyceride is one of the major fatty substances in the blood. Another is cholesterol. High blood levels of triglycerides are often associated with high cholesterol levels, which are a primary cause of heart disease. An extremely high level of triglycerides in the blood also increases the risk of *pancreatitis* (inflammation of the pancreas).

Each triglyceride molecule consists of one molecule of glycerol combined with three molecules of fatty acids. Triglycerides are consumed in food. During digestion, they break down into separate molecules of fatty acids and glycerol. These molecules may be used by cells for energy, or they may be recombined into triglycerides and stored as fat for later use.

In adults, a triglyceride level of less than 200 milligrams per decilitre of blood is considered desirable. Higher triglyceride levels are often associated with an increased risk of heart disease. People who have triglyceride levels of more than 1,000 milligrams per decilitre are at high risk of pancreatitis.

Several factors lead to elevated triglyceride levels. They include alcohol, stress, weight gain, certain medications, and a diet high in carbohydrates. People can lower their triglyceride levels by reducing the amount of calories and fat in their diet and by regular exercise.

See also **Cholesterol; Fat.**

Trigonometry is a branch of mathematics that deals with the relationships between the sides and angles of triangles. It also provides methods of measuring these sides and angles. Trigonometry has applications in such theoretical sciences as physics and astronomy, and in such practical fields as surveying and navigation. The word *trigonometry* comes from two Greek words meaning *triangle* and *measure.*

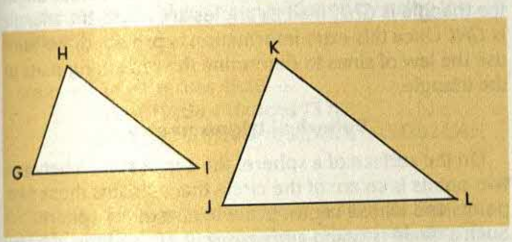
There are two kinds of trigonometry—*plane trigonometry* and *spherical trigonometry.* Plane trigonometry is used to determine the unknown sides and angles of triangles that lie in a plane. Spherical trigonometry can be used to find the unknown sides and angles of triangles that lie on a spherical surface.

Both types of trigonometry are based on relationships that exist between the six parts—three sides and three angles—of any triangle. Because of these relationships, in most cases any three parts whose measures are known can be used to find the measures of the other three, if at least one of the known parts is a side. It is necessary to know the length of at least one side because the corresponding sides of two triangles may be unequal even though all their corresponding angles are equal.

Trigonometry is based on a type of geometry called *Euclidean geometry.* Euclidean geometry was developed from a set of assumptions spelled out about 300 B.C. by the Greek mathematician Euclid (see **Geometry** [Types of geometry]). Spherical trigonometry was first described about A.D. 150 in a work by Ptolemy of Alexandria called the *Almagest.* Plane trigonometry was developed in the 1400's by the German mathematician Johann Müller, who was also known as Regiomontanus.

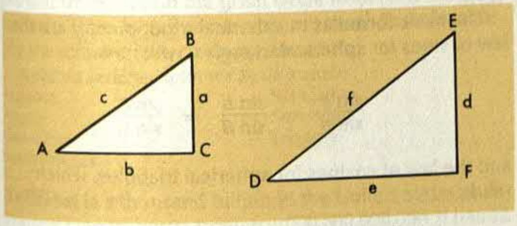
Plane trigonometry

To understand trigonometry, it is necessary first to study the properties of *similar triangles.* Two triangles are said to be similar when all the corresponding angles of the triangles are equal. For example, the triangles *GHI* and *JKL* shown below are similar if angle G = angle J, angle H = angle K, and angle I = angle L. The corresponding sides of similar triangles need not be equal.



However, they are in proportion. Therefore, if triangles *GHI* and *JKL* are similar, the ratio *GH:GI* will equal the ratio *JK:JL.* Suppose that $GH = 3$ units, $GI = 5$ units, and $JK = 9$ units. Then $JL = 15$ units, because $\frac{3}{5} = \frac{9}{15}$.

Right-angled triangles. Trigonometry is largely derived from the study of similar *right-angled triangles.* A right-angled triangle is any triangle in which one of the angles equals 90°. The three angles in any triangle total 180°. Therefore, every right-angled triangle has two acute angles that total 90°. If we know one of the acute angles, we can find the other one by subtracting the known angle from 90°. In addition, if an acute angle of one right-angled triangle equals an acute angle of a second right-angled triangle, then the two triangles are similar. In the right-angled triangles *ABC* and *DEF* below, for example, angle *C* and angle *F* are right angles and angle *A* equals angle *D.* Therefore, the two triangles are similar. And because they are similar, their sides must be in proportion, so $\frac{a}{c} = \frac{d}{f}$, $\frac{b}{c} = \frac{e}{f}$, and $\frac{a}{b} = \frac{d}{e}$.



The ratios that make up these proportions will equal the ratios for the corresponding sides of any right-angled triangle that has an acute angle equal to angle *A.* Each of the possible ratios between the sides of a right-angled triangle has been given a name. In the illustration above, for example, the ratio $\frac{a}{c}$ is called the *sine* of angle *A,* and is written **sin** ***A.*** The ratio $\frac{b}{c}$ is called the *cosine* of angle *A.* It is written **cos** ***A.*** The ratio $\frac{a}{b}$ is called the *tangent* of angle *A,* and is written **tan** ***A.*** Mathematicians have compiled tables of the values of these ratios for all the possible angles of a right-angled triangle. Such tables have been programmed into scientific calculators.

Trigonometric tables also include three rarely used ratios called the *secant, cosecant,* and *cotangent.* The secant of angle *A,* written **sec** ***A,*** is $\frac{c}{b}$. The cosecant of angle *A,* written **csc** ***A,*** is $\frac{c}{a}$. The angle's cotangent, written **cot** A, is $\frac{b}{a}$.

The following are formal definitions of the six trigonometric ratios:

$$\text{sine} = \frac{\text{side opposite the angle}}{\text{hypotenuse}}$$

$$\text{cosine} = \frac{\text{side adjacent to the angle}}{\text{hypotenuse}}$$

$$\text{tangent} = \frac{\text{side opposite the angle}}{\text{side adjacent to the angle}}$$

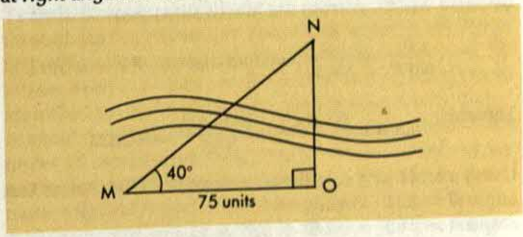
$$\text{secant} = \frac{\text{hypotenuse}}{\text{side adjacent to the angle}}$$

$$\text{cosecant} = \frac{\text{hypotenuse}}{\text{side opposite the angle}}$$

$$\text{cotangent} = \frac{\text{side adjacent to the angle}}{\text{side opposite the angle}}$$

The trigonometric ratios make it possible to find all three sides of the right-angled triangle *ABC* if we know the measure of one of the acute angles and the length of any side. For instance, if angle *A* is 30°, then we can use a table or calculator to determine that $\sin A = \frac{1}{2}$. And if $\sin A = \frac{1}{2}$, then $\frac{a}{c} = \frac{1}{2}$. Thus, if side *c* is 9 units long, then side *a* must be $4\frac{1}{2}$ units long.

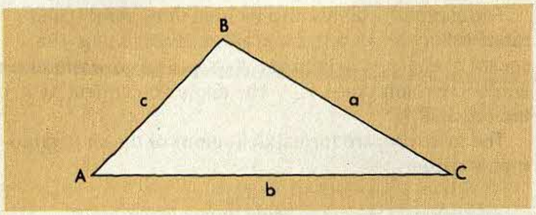
This method has many applications. For example, suppose you are standing at point *O* on the bank of a river and looking at a tree at point *N* on the opposite shore (see the figure below). You can use this method to find the distance from *O* to *N* without crossing the river. First, place a marker at point *O.* Then, walk along a line at right angles to the line *NO* until you come to a convenient point *M,* thus forming the right-angled triangle *MNO.* Next, measure the length of the line *MO.* If *MO* is, say, 75 units long, and angle *M* measures 40°, you can use a calculator or table to determine that $\tan 40° = 0.8391$. Because $\tan M = NO/MO$, $NO = (MO)(\tan 40°) = (75\text{ units})(0.8391) = 62.93$ units.



The law of sines. For some applications, you must determine the unknown parts of a triangle that is not a right-angled triangle. If you know two angles and one side of such a triangle, you can find the other two sides and the other angle by using the *law of sines.* This law says:

For a triangle *ABC* with sides *a, b,* and *c* (see figure),

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$



If we know angle A and angle B, we can determine angle C, because angle $C = 180° - (\text{angle } A + \text{angle } B)$. If we know side c, we can then find sides a and b, because from the law of sines we know that

$$b = \frac{c\,(\sin B)}{\sin C} \quad \text{and } a = \frac{c\,(\sin A)}{\sin C}$$

The law of cosines. If we know two sides of a triangle that is not a right-angled triangle, and the angle between them, the remaining parts of the triangle can be found by using the *law of cosines.* The law of cosines states:

For a triangle ABC with sides a, b, and c,

$$c^2 = a^2 + b^2 - 2ab(\cos C).$$

For example, if we know sides a and b and angle C, we can find side c by the law of cosines. We can then use the law of sines to find the other two angles. Thus, if side $a = 5$ units, side $b = 7$ units, and angle $C = 52°$, we can solve for the unknown side and angles of the triangle. Using a table or a calculator, we can determine that $\cos 52° = 0.6157$. We can then use the law of cosines to solve for c^2:

$$\begin{aligned} c^2 &= [(25 + 49) - (70 \times 0.6157)] \\ &= 30.90 \end{aligned}$$

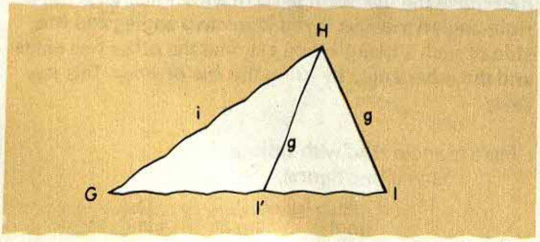
Then, we calculate that $c = \sqrt{30.901} = 5.56$ units. Next, because we know from the law of sines that

$$\frac{b}{\sin B} = \frac{c}{\sin C}, \text{ we find that } (\sin B)\ c = b\,(\sin C).$$

Therefore, $\sin B = \dfrac{b(\sin C)}{c} = \dfrac{7(\sin 52°)}{5.56} = 0.9922.$

Using a table or a calculator, we can then determine that angle $B = 82.8°$. Finally,
angle $A = 180° - (82.8° + 52°) = 45.2°$.

A special case. There is only one case in which we must know more than the measures of three parts of a triangle to solve for the triangle's unknown sides and angles. This case occurs when we know two sides and one angle, but the known angle is not between the two known sides. In such a case, the triangle could take two possible forms. In the figure below, for example, if we know only angle G and sides g and i, then the triangle may be either triangle GHI or triangle GHI'.



The two possibilities for the angle opposite side i are GIH and $GI'H$. These two angles are *supplementary*—that is, they total 180°. Sines of supplementary angles are equal, so **sin** angle $GIH =$ **sin** angle $GI'H$. Thus, we cannot use the law of sines to determine which angle is part of the unknown triangle. To solve the triangle, we must know whether the triangle has an obtuse angle or whether all its angles are acute. If it has an obtuse angle, the triangle is GHI'. If all its angles are acute, the triangle is GHI. Once this extra information is provided, we can use the law of sines to determine the remaining parts of the triangle.

Spherical trigonometry

On the surface of a sphere, the shortest path between two points is an arc of the circle that contains those two points and whose centre is the centre of the sphere. Such a circle is called a *great circle.* On a globe, the circles of longitude, which pass through the North Pole and the South Pole, are great circles. The circles of latitude, except for the equator, are not great circles because their centres lie above or below the centre of the sphere. Arcs of circles are measured in degrees. A complete circle measures 360 degrees. The circumference of a great circle on the earth is about 40,008 kilometres. Thus, each degree of arc of a great circle on the earth extends about 111.13 kilometres. The angle between two great circles is the angle between their *tangents* at the point of intersection. A tangent is a line that touches an arc at one point only, without intersecting it. A *spherical triangle* is formed by the intersections of three great circles.

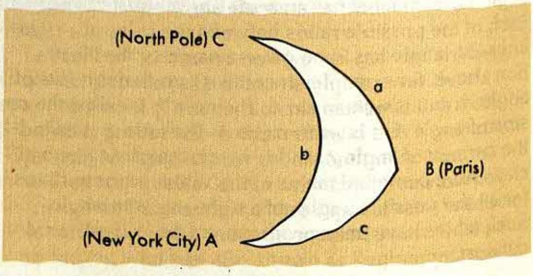
Because both the angles and the sides of a spherical triangle are measured in degrees, the formulas of spherical trigonometry differ somewhat from the formulas of plane trigonometry. Also, spherical triangles differ from plane triangles in that the angles of a spherical triangle always total more than 180°. However, spherical trigonometry uses the same tables that plane trigonometry uses.

The basic formulas in spherical trigonometry are the law of sines for spherical triangles, which reads:

$$\frac{\sin a}{\sin A} = \frac{\sin b}{\sin B} = \frac{\sin c}{\sin C}$$

and the law of cosines for spherical triangles, which reads:

$$\cos c = (\cos a)(\cos b) + (\sin a)(\sin b)(\cos C).$$



The figure shows how these laws are applied. The distance from New York City to Paris is calculated by drawing a spherical triangle whose vertices are New York City, Paris, and the North Pole.

Because the longitude of Paris is 2.20° east and the longitude of New York City is 73.58° west, angle C is $2.20° + 73.58°$, or 75.78°. Because the latitude of Paris is 48.51° north, arc a is $90° - 48.51°$, or 41.49°. Because the latitude of New York City is 40.40° north, arc b is $90° - 40.40°$, or 49.60°. By the law of cosines for spherical triangles, the measure of arc c can be found by using the equation:

$$\begin{aligned}\cos c &= (\cos 41.49)(\cos 49.60) + \\ &\quad (\sin 41.49)(\sin 49.60)(\cos 75.78) \\ &= (0.74907)(0.64812) + (0.66249)(0.76154)(0.24565) \\ &= 0.60942\end{aligned}$$

We can use a table or calculator to determine that 0.60942 is the cosine of a 52.45° arc. Therefore, arc c is 52.45°, and because one degree of arc of a great circle corresponds to a distance of 111.13 kilometres, the distance from New York City to Paris is 111.13 kilometres × 52.45, or 5,829 kilometres.

To find the direction in which Paris lies in relation to New York City, we find the measure of angle A by using the law of sines for spherical triangles:

$$\begin{aligned}\frac{\sin a}{\sin A} &= \frac{\sin c}{\sin C} \\ (\sin A)(\sin c) &= (\sin a)(\sin C) \\ \sin A &= \frac{(\sin a)(\sin C)}{\sin c} \\ &= \frac{(0.66249)(0.96936)}{0.79282} \\ &= 0.81000.\end{aligned}$$

We can use a table or calculator to determine that 0.81000 is the sine of an angle of 54.1°. Therefore, angle A is 54.1°. From New York City, therefore, the compass direction to Paris is 54.1° east of north. But the angle between the direction to Paris and the north changes as a person travels along the great circle from New York City to Paris. Therefore, a person cannot reach Paris by simply travelling in this compass direction.

Related articles in ***World Book*** include:

- Algebra
- Angle
- Geometry
- Mathematics
- Navigation
- Surveying
- Triangle

Trillion is a thousand billion in the United States and France. One trillion is written 1,000,000,000,000. It has 12 zeros. Other countries have adopted this meaning of trillion. In the United Kingdom and Germany, a trillion was a billion billion, and had 18 zeros. See also **Decimal system** (The decimal system and number words).

Trillium is a wild flower that grows in damp, wooded places in North America and Asia. There are about 40 kinds. The greatest number of these are found in the southern Appalachian Mountains of the United States. The flowers have three sepals, three petals, and six stamens. Each stem bears one flower and three leaves. The best-known trillium is the North American *white trillium.* The flowers are borne on short, arching stems. They are white on opening and become flushed with pink. The *painted trillium* is the most colourful. Its white flowers have deep pink or purple stripes.

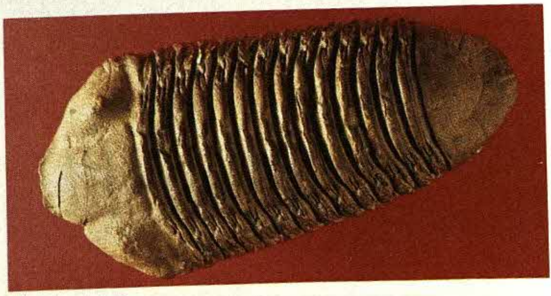
Trillium thrives in damp, wooded places. The flowers have three petals each, and are borne on short, arching stems.

Scientific classification. Trilliums belong to the lily family, Liliaceae. The white trillium is *Trillium grandiflorum;* the painted trillium is *T. undulatum.*

See also **Flower** (picture: Flowers of woodlands and forests).

Trilobite was a prehistoric sea animal. It lived throughout the *Palaeozoic Era,* which lasted from about 570 million years ago to about 240 million years ago. Trilobites lived in all parts of the world, and scientists have identified over 10,000 species from fossils. A soft shell covered much of the animal's body. Most trilobites were under 10 centimetres long. Two grooves divided the animal's shell lengthwise into three *lobes* (sections). The name *trilobite* means *three lobes.* The body had three main parts: the head, the thorax, and the tail. The thorax had many segments, each bearing legs. The trilobite breathed through gills on the legs.

Scientific classification. Trilobites belong to the phylum Arthropoda.



A fossil of a trilobite

Trinidad and Tobago is an independent country in the West Indies. The territory consists of two main islands—Trinidad and Tobago—and 21 smaller islands. It is located in the southeastern Caribbean Sea at the southern end of the Lesser Antilles chain of islands. Trinidad, the larger of the two main islands, lies with its southwestern tip only 11 kilometres from the coast of Venezuela. Tobago lies 32 kilometres northeast of Trinidad.

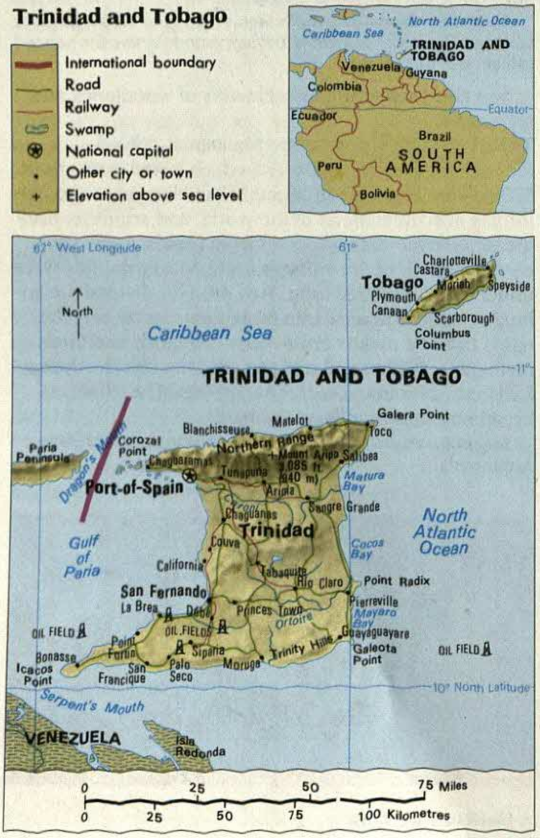
The country's capital is Port-of-Spain, a city of about 60,000 people in the northwestern corner of Trinidad. Tobago's capital, Scarborough, lies in the south of that island.

Trinidad and Tobago is the home of calypso, steel bands, and carnival. It is also the birthplace of such famous cricketers as Sir Learie Constantine and Brian Lara (see **Lara, Brian; Constantine, Sir Learie**).

Government

Trinidad and Tobago is a republic within the Commonwealth of Nations. Its head of state, the president, is elected by an electoral college consisting of the members of the House of Assembly, the lower house of the country's *bicameral* (two chamber) parliament. The House of Representatives has 36 members elected by the people. The upper house, called the Senate, has 31 members appointed by the president. Of these, 9 are appointed at the president's own discretion, 16 on the advice of the prime minister, and 6 on the advice of the leader of the opposition. The prime minister is the head of the majority political party in the parliament. National elections to the parliament are held every five years. Everyone aged 18 or over has the right to vote. Tobago has some autonomy in a separate House of Assembly, which controls some of its domestic affairs.

Oil is important to Trinidad's economy. The oil terminal, *above,* is at Galeota Point, in southeast Trinidad.



Trinidad and Tobago

People

Population and ancestry. For the total population of Trinidad and Tobago, see the *Facts in brief* table with this article. About 94 per cent of the country's inhabitants live in Trinidad, 4 per cent live in Tobago, and the rest inhabit the other small islands of the territory. Less than 9 per cent of Port-of-Spain's population live in the city's business and commercial centre. The rest of its population live in the surrounding suburbs.

About 43 per cent of the residents of Trinidad and Tobago are of African descent. Another 41 per cent are East Indian, 16 per cent are of mixed origin, and the rest are made up of Chinese, Europeans, Syrians, Lebanese, and others.

Language. English is the official language. But some people regularly speak Hindi or a French *patois* (dialect).

Facts in brief about Trinidad and Tobago

Capital: Port-of-Spain.
Official language: English.
Total land area: 5,128 km². *Coastline*—470 km.
Elevation: *Highest*—Mt. Aripo, 940 m. *Lowest*—sea level.
Population: *Estimated 1996 population*—1,317,000; density, 264 people per km²; distribution, 69 per cent urban, 31 per cent rural. *1990 census*—1,234,388. *Estimated 2001 population*—1,375,000.
Chief products: Asphalt, oil, petrochemicals, sugar.
National anthem: "Forged from the Love of Liberty."
Flag: A black stripe, bordered by white stripes, runs across a red field from the upper left- to the lower right-hand corner. See **Flag** (picture: Flags of the Americas).
Money: *Currency unit*—Trinidad and Tobago dollar. One dollar = 100 cents.

The prime minister's office, *above,* is in Port-of-Spain, the capital of Trinidad and Tobago.

Spanish is also in wide use. Many people speak Trinidadian English, a form of English with French and Spanish influences.

Religion. Nearly 34 per cent of the population of Trinidad and Tobago are Roman Catholic, 25 per cent are Hindu, 15 per cent Anglican, 6 per cent Muslim, and 4 per cent Presbyterian. The rest are made up of Seventh-day Adventists and other groups.

Education. Education is provided in Trinidad and Tobago through a network of primary, secondary, and technical schools, and teacher-training institutions. Port-of-Spain, Centeno, and San Fernando each have a technical institution. In addition, one of the three campuses of the University of the West Indies is located in Trinidad. It is at Saint Augustine, about 13 kilometres east of Port-of-Spain. This campus houses the faculties of education, engineering, law, medicine, social science, natural science, liberal arts, and agriculture. Education is free at the primary and secondary levels and is compulsory for children aged 6 to 12 years.

Way of life

Nearly 70 per cent of Trinidad and Tobago's inhabitants live in urban communities. People regularly wear Western-style light summer clothing but wear extravagant and colourful costumes when taking part in Trinidad's famous carnival. Cultural differences in dress and family life exist between African and East Indian communities.

Housing is a major problem in Trinidad and Tobago. The shortage of homes is due chiefly to high construction costs, a lack of available land, and recent population movements.

Recreation and sport. People in Trinidad and Tobago have a keen interest in sports. Cricket is the most important game. Football (also known as soccer) and athletics are also popular.

Culture. The people of Trinidad and Tobago enjoy a rich cultural tradition. The distinctive West Indian musical form of the *calypso* originated in Trinidad during the 1800's. The calypso music, which is now part of the West Indian people's way of life, is a cultural and artistic expression of the political, economic, and social situation. It has been described as a development of African folk music, with French creole and Spanish influences. The rhythmic music varies from a moderately slow to a fast and pulsating tempo. The lyrics also vary from topical political issues to witty satire, sexual innuendo, and comedy. Calypso mostly consists of verses and a chorus or refrain.

Calypso is often an accompaniment for dancing, whether in the street, at a Trinidadian nightclub, in a dance hall, or at a *fete* (party). One famous dance performed to a calypso rhythm is the *limbo.* The limbo dance is more a competition than a real dance. A horizontal pole is set up between two vertical poles in such a way that the height of the horizontal pole above the ground can be adjusted. The limbo dancer bends over backward and weaves under the horizontal pole to the rhythm of the music. The dancer must touch neither the pole nor the ground. Then the pole is lowered and the dancer tries again. Two or more limbo dancers may compete with each other in passing underneath a pole that is lowered progressively closer to the ground.

Calypso music is popular at any time during the pre-Lenten season, the time when the carnival takes place. Trinidad boasts the grandest and most spectacular carnival in the Caribbean. At carnival time, people throw caution to the winds and enjoy themselves. The carnival tradition goes back at least 200 years. It began under Spanish rule, but French sugar planters who moved to Trinidad in 1783 encouraged its growth. The carnival season lasts from Christmas to Ash Wednesday. It originally consisted of masked balls, hunting parties, and outdoor festivities. French people who took part wore disguises and were accompanied by musicians.

A limbo dancer, *above,* has to bend backward to pass under a bar. The bar is gradually lowered, and some are able to pass under a bar that is only 15 centimetres from the ground.

In 1833, when slavery ended, carnival underwent a sudden change. Masses of ex-slaves began taking part in street celebrations in the pre-Lenten period. Revellers went around in bands wearing elaborately decorated costumes. During the 1900's, the carnival grew into its present form. Today, colourful and spectacular parades of marchers and *floats* (specially adapted and decorated vehicles), depict a wide range of subjects. These include historical and topical events and personalities, artistic creations, and traditional presentations, with stock characters such as clowns, bats, dragons, and devils. Carnival participants spend much time and money in making their elaborate and decorative displays.

In Trinidad, the most important carnival days are the Monday and Tuesday before Lent. On the days leading up to them, there are children's competitions, including Junior Carnival King and Queen contests, steel band competitions, and numerous parties. *Dimanche Gras (Fat Sunday)* takes place on the Sunday evening. This is a high point of the carnival, when the Carnival King and Queen are chosen. The calypso competition also takes place at this time, as "calypsonians" vie for the title of Calypso Monarch.

On the Monday of carnival, Trinidad awakens to *jour ouvert* (the break of day), which is the signal for people to join in all the street parties that have gone on all through Sunday night. Parades and competitions continue through Monday and Tuesday, building up to Tuesday midnight. All the festivities go on to the rhythm of the calypso.

The steel band is allied to the calypso and it, too, originated in Trinidad. Steel bands provide a lively musical accompaniment to the carnival. They consist of groups of instruments, known as *pans,* the local name for the metal containers (traditionally oil drums) from which the instruments are made. The steel band sound has evolved to produce a variety of rhythms, from classical to calypso. Steel band competitions are held during the carnival, when numerous bands display their mastery of the art form. See **Carnival; Steel band.**

East Indian cultural influences show themselves through such festivals as Diwali, the Festival of Lights, an annual Hindu festival held during October or November. Hindus light up their surroundings with small earthenware lamps. At Christmas, people take part in *parangs,* musical performances that show the influence of the Spaniards on Trinidad's cultural life. Spanish influence can also be seen in the architecture of Port-of-Spain.

Land and climate

The island of Trinidad is roughly rectangular in shape, with three of its corners drawn out into peninsulas. It covers an area of 4,826 square kilometres, and accounts for about 95 per cent of the total land area of the country of Trinidad and Tobago. The island of Tobago is just 300 square kilometres in area.

Trinidad is separated from Venezuela by the Gulf of Paria. This gulf is bounded by Trinidad's northwestern and southwestern peninsulas. Shipping can enter the Gulf from the north through the Dragon's Mouth (Boca del Dragon) and from the south through the Serpent's Mouth (Boca del Sierpe). There are several small islands around the coast of Trinidad and Tobago which are wildlife reserves.

Forests cover half of Trinidad. There are also three mountain ranges—the northern, which stretches across the entire northern section of the island, a central range, and a range of undulating hills to the south. Trinidad's highest peak, Mount Aripo (940 metres above sea level) is in the northern range. Trinidad has three plains, each with large swampy areas. One of these swamps, the Caroni, is home to the Scarlet Ibis, the national bird.

Tobago has a central mountain ridge and scenic beaches. Its highest peak, the Main Ridge, is 549 metres above sea level. To its west and south, the land is flat or gently undulating.

Carnival in Trinidad is a popular event in which almost everyone takes part. Trinidadians dress up in elaborate and colourful costumes, *left,* and paint their faces, *above.* A prize is awarded for the best costume.

The Pitch Lake is a natural deposit of asphalt, a syrupy substance used worldwide for paving roads.

Trinidad's climate is tropical with maximum temperatures of 33 °C. The year-round average is 26 °C. Tobago is cooler, because it is exposed to the trade winds. The rainy season is usually from June to December, which may be interrupted in September and November by a short dry spell called the *Petit Carème* (Little Lent). Average annual rainfall ranges from 125 centimetres in southwestern Trinidad to 250 centimetres in the mountains of Tobago. Hurricanes occur mostly during the rainy season.

Economy

Service industries such as government services, freight and passenger transport, storage, telecommunications, and distributive trades dominate the economy of Trinidad and Tobago. Services account for 55 per cent of the country's *gross domestic product* (GDP, the total value of all goods and services produced within a country during one year). The petroleum industry, once the region's chief support, still supplies 3 per cent of GDP and produces millions of barrels of oil a year. Construction and quarrying contributes 9 per cent. Pitch Lake, in Trinidad, is a major source of asphalt for use in road surfacing. Manufacturing supplies 9 per cent of GDP and consists mainly of heavy industries producing petrochemicals, methanol, iron, steel, and cement, and light industries such as clothing. Trinidad and Tobago's main agricultural products are sugar, rice, vegetables, and *ground provisions* (root vegetables and tubers).

Oil and petrochemicals account for more than 80 per cent of the country's total export earnings. Oil companies work oilfields in the south of Trinidad and off the island's southern coast. The tourist sector of the economy does not contribute much to foreign exchange earnings.

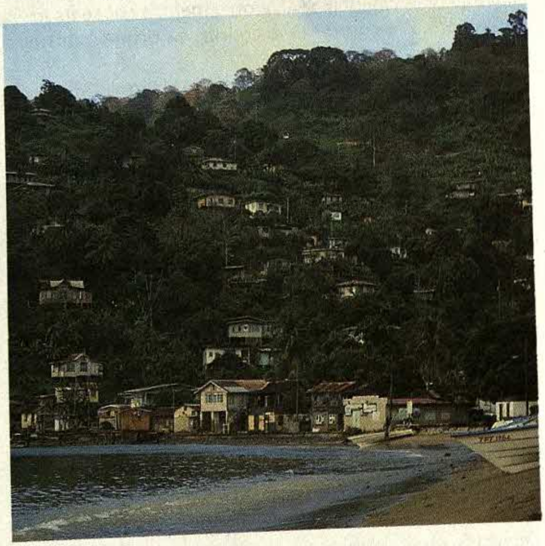
Trinidad's main exports, apart from petroleum products, include chemicals and manufactured goods. Its main export markets are in the United States and members of the Caribbean trading community CARICOM. The main sources of imports are the United States, Venezuela, the United Kingdom, Japan, and Brazil.

History

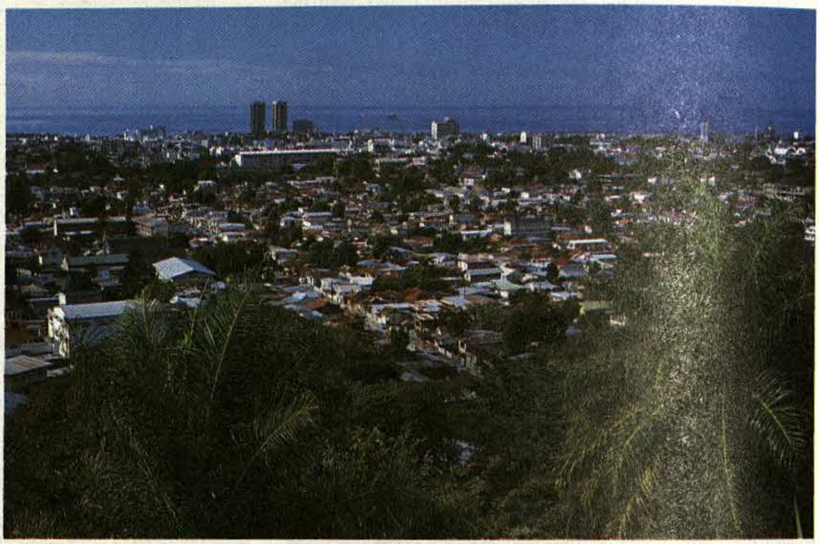
Historians believe that several distinct peoples inhabited Trinidad prior to the arrival of the Spanish. These early settlers, from South America, include the Arawak and possibly the Carib. They depended mainly on fishing and agriculture, cultivating cassava, maize, sweet potatoes, and fruit. They lived in *ajoupas* (huts with a round irregular shape and thatched roof). Some villages, such as Tacarigua, Coura, and Arouca, still bear Arawak names.

Christopher Columbus arrived in Trinidad in 1498. His son Don Diego Colón was one of the first Spanish colonists to settle on the island in the early 1500's. Trinidad remained in Spanish hands from 1498 to 1797. These were years of mismanagement and neglect during which the pre-Columbian settlers were enslaved and forced to work on plantations. In 1699, these people rebelled against Spanish rule and against the Christian missionaries in Trinidad. The revolt led to the murder of some friars, the burning of the mission, and the death of the island's Spanish governor. The Spanish retaliated, chasing the rebels to the coast. Having reached the tip of Point Galera, many chose to throw themselves into the sea rather than be captured by the Spaniards. The surviving pre-Columbian settlers were moved on to a reservation. Meanwhile, their places in the plantation labour force were taken by slaves imported from Africa. In 1783, French planters from neighbouring islands moved to Trinidad, bringing their African slaves with them.

The British captured Trinidad from the Spaniards in 1797 and formally gained possession of it in 1802. In 1834, the United Kingdom government ended slavery in the colonies. Most slaves withdrew their labour from the plantations. In Trinidad, the ex-slaves had the option of acquiring land, and planters were forced to fill the labour shortage created because of their departure by im-



Tobago is a tranquil holiday island with scenic beaches. Charlotteville, *above,* is a bay on the northeastern coast.



Port-of-Spain is the capital and largest city in Trinidad and Tobago. The city is an industrial centre with a deepwater harbour.

porting *indentured workers* (workers held under contract to a master) from India.

The first attempt at European settlement in Tobago was in 1632. The island changed hands several times between various European powers during the 1600's and 1700's. It was ceded to the British in 1814 under the Treaty of Paris. Tobago was joined in political union with the Windward Islands and Barbados in 1833. In 1889, Tobago was incorporated with Trinidad to form the colony of Trinidad and Tobago.

In 1958, Trinidad and Tobago became part of the West Indies Federation, the headquarters of which was located in Trinidad. When this federation was dissolved in 1962, Trinidad and Tobago became independent under the leadership of the writer and scholar Eric Williams. Williams, whose political career began in 1955, first gained power in 1956 when his party, the People's National Movement (PNM), won a majority of seats in parliament. Williams led the country as prime minister until his death in 1981.

In 1986, the PNM lost power to the National Alliance for Reconstruction (NAR), led by Ray Robinson. The NAR tried to halt economic decline by means of tough economic measures backed by the International Monetary Fund (IMF). The measures proved unpopular and the PNM returned to power in 1991 under Prime Minister Patrick Manning.

Trinidad was rocked by a coup attempt in July 1990. The Jamaat al-Muslimeen, a Muslim group led by Abu Bakr, held the parliament hostage for six days. The incident resulted in the death of 30 people and injury of 69 others. The attempted coup failed because of the lack of support from the mass of the people.

Related articles in *World Book* include:

Arawak Indians
Capildeo, Rudranath
Carib Indians
Cazabon, Michel
Chambers, George
Columbus, Christopher
De Boissiere, Ralph
Hassanali, Noor
John, Errol
Matura, Mustapha
Naipaul, Shiva
Naipaul, V. S.
Port-of-Spain
Robinson, Ray
Selvon, Samuel
Williams, Eric

Trinitrotoluene. See TNT.

Trinity is a term used to express the belief that in the one God there are three Divine Persons—the Father, the Son, and the Holy Spirit (or Holy Ghost). The idea is based on various passages in the New Testament. Belief in Father, Son, and Holy Spirit was defined by early general councils of the Christian church. The Council of Nicaea in 325 and the Council of Constantinople in 381 declared that the Son is of the same essence as the Father, and that the three Persons are one God. The East and West branches of the church later disagreed as to how the Holy Spirit proceeds from the other Divine Persons. The Eastern Church held that the Son comes from the Father, and that the Spirit comes from the Father through the Son. The Western Church held that the Spirit comes from Father and Son together. A special activity has been ascribed to each of the Persons. The Father creates, the Son became human, and the Spirit makes holy. See also **Nicene Councils; Arianism.**

Trinity House is the lighthouse authority for England, Wales, and the Channel Islands. Its official name is The Corporation of Trinity House. Trinity House controls 82 lighthouses, 11 lightvessels, and about 550 buoys. The corporation's business is controlled by *Elder Brethren* (experienced seamen). Trinity House also has power to inspect seamarks maintained by other authorities. Its other responsibilities include dealing with wrecks. See also **Lighthouse.**

Trip. See **LSD.**

Tripe is a meat that comes from the stomach walls of cattle. Such animals have stomachs that consist of four compartments. Tripe is produced from the first two compartments. Most tripe is white, and the meat has little taste. *Honeycomb tripe,* which comes from the lining of the second compartment, has a netlike appearance.

Tripe is sold canned, fresh, frozen, or pickled. People bake, grill, or fry tripe, or they cook it in water. Meat-processors sometimes use tripe as one of the ingredients of sausage.

Triple Alliance was a defence agreement among Austria-Hungary, Germany, and Italy. It lasted from 1882 until World War I. The three nations agreed to help one another in case of attack by two or more great powers. Austria-Hungary and Germany also agreed to help Italy in case of attack by France, and Italy agreed to help Germany if France attacked that nation. The three countries renewed the alliance several times, the last time in 1912. See also **Bismarck, Otto von** (Bismarck's diplomacy); **World War I** (A system of military alliances).

Triple Entente means *triple,* or *threefold, agreement.* When World War I broke out in 1914, the chief powers of Europe formed two opposing groups. Germany, Austria-Hungary, and Italy made up the Triple Alliance, while the United Kingdom, France, and Russia formed the Triple Entente (see **Triple Alliance**).

The Triple Entente was only an informal grouping when first formed. But between 1912 and 1914, it became an effective diplomatic combination. After the outbreak of war, the Entente Powers signed the Declaration of London, in which each power agreed not to make a separate peace. This act transformed the Triple Entente into a formal union.

See also **World War I** (A system of military alliances).

Triple jump is an athletics event in which an athlete leaps as far as he or she can in three continuous jumps. The event, once called the *hop, step, and jump,* requires a blend of speed, strength, and technique.

In the triple jump, the athlete sprints down a runway to a take-off point, usually a wooden board 20 centimetres wide. The athlete then jumps forward on one foot, lands on the same foot, jumps forward again, lands on the other foot, and then leaps into a sand-filled landing pit. The jump is measured from the front edge of the take-off point to the mark in the sand nearest that point. If the jumper's foot crosses the front edge of the take-off point as he or she jumps, the attempt is a foul. In most competitions, each jumper gets six attempts. The winner is determined by the longest fair jump.

See also **Athletics** (Jumping events; table); **Olympic Games** (table: Track and field).

Triplets. See **Multiple birth.**

Tripoli (pop. 175,000) is the second largest city in Lebanon. Only Beirut has more people. Tripoli's name in Arabic is Tarabulus. A seaport and industrial centre, Tripoli lies on Lebanon's northwest coast, at the eastern end of the Mediterranean Sea. For location, see **Lebanon** (map). The city's chief industries include trade and services; petroleum refining; the manufacture of furniture, soap, and textiles; and sponge fishing. Citrus fruit are grown in and around Tripoli.

The Castle of St. Gilles, built by crusaders before A.D. 1200, overlooks the city. The Teylan Mosque, built in the traditional Arab style, dates from 1336. Tripoli's name, which means *Three Cities,* is related to its founding. Colonists from three Phoenician cities—Aradus, Sidon, and Tyre—founded the city in the 300's B.C.

Tripoli (pop. 990,697) is the capital and largest city of Libya. Its Arabic name is Tarabulus. Tripoli lies in northern Libya, along the Mediterranean Sea. For location, see **Libya** (map).

Tripoli has a fine harbour and is a shipping centre. It is also a trading centre for a farming region. Tripoli's industries include oil refining, food processing, and the production of such handicrafts as woven carpets and leather goods. The old city centre of Tripoli is surrounded by stone walls. It features a Roman arch that dates from the A.D. 100's and a palace and garden built in the 1500's. Since the 1970's, many modern high-rise buildings have been constructed in the city.

Tripoli is the capital of Libya, in North Africa. The city is a shipping and trading centre.

Tripoli was founded by Phoenicians, probably in the 600's B.C. It was originally called Oea. It was later named Tripoli, which means *Three Cities.* The name refers to the ancient district of Tripoli, which included three cities—Oea, Leptis Magna (now Lebda), and Sabratha.

From the mid-1500's to 1911, Tripoli was part of the Ottoman Empire—which was centred in what is now Turkey—and the capital of the surrounding province called Tripolitania. But the local rulers in Tripoli had almost complete freedom during much of the period. Attacks by Barbary pirates of North Africa on U.S. shipping led to a war between the United States and Tripoli in 1801. Italy conquered Tripoli in 1911 and ruled it until World War II (1939-1945).

See also **Barbary States.**

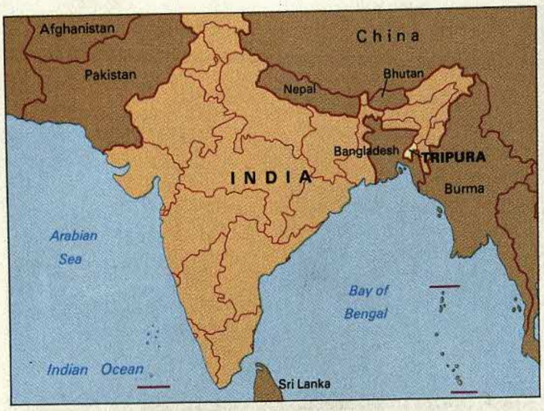
Tripura is a small, mainly agricultural state in northern India. It is partly mountainous with several deep river valleys. It is located in the monsoon belt (see **Monsoon**). The moist, mountainous areas of the state have a rich cover of evergreen forest. The south is more open and densely populated. The capital of Tripura, Agartala, is in the south of the state.

People and government. More than half of the population of Tripura are Hindus. The rest are Christians, with small minorities of Muslims and Buddhists. More than half of the population speak Bengali. Tripuri and Manipuri are also widely spoken languages.

Tripura has two elected members in the *Lok Sabha* (lower house) and one nominated representative in the *Rajya Sabah* (upper house) of the Indian national parliament. The state legislative assembly has 60 members.

Economy. Rice is the main food crop. It is well suited to the marshy areas of the northern valleys and the low-lying plain in the south. Jute and tea are the major cash crops. Cotton, fruit, *mesta,* mustard, potatoes, and sugar cane are also grown. Mesta is a plant grown for its fibre, which is used for sacking and cordage.

Manufacturing. Tripura's main manufacturing activity is the processing of its cash crops, jute and sugar cane. However, there are no large-scale factories. Small



Tripura is a partly mountainous Indian state which lies to the east of Bangladesh.

factories process such items as fruit for canning, tea, and timber. Other small manufacturing industries are developing in the state with government encouragement. Basket making, carpentry, pottery, and weaving are common. Other products include aluminium utensils, leather goods, plywood, and steel furniture. Tripura also has flour and rice mills and sawmills. *Sal,* an Indian hardwood, and charcoal are the main forest products. *Sericulture* (the rearing of silkworms for the production of raw silk) is developing fast.

The only convenient means of travel to Agartala is by air. There are daily flights to and from Calcutta, in West Bengal, as well as connections to Gauhati and Silchar, both in Assam. There are less than 1,300 kilometres of surfaced road in the state. Tripura is a great distance from major Indian cities. Calcutta is more than 1,800 kilometres away, Gauhati 600 kilometres, and Shillong 500 kilometres away. There are no railways.

Land. Tripura is a hill state in northeastern India. Bangladesh surrounds it on the north, west, and south. The Indian states of Mizoram and Assam border it on the east and northeast. The north of the state consists of four valleys, separated by ranges of hills. The most easterly range rises to nearly 1,000 metres. Northward draining rivers include the Deo, the Dhalai, the Khowai, and the Manu. The Gumti and its tributaries drain the plain in the south of Tripura. Much of the original evergreen forest has now been cleared. *Sal,* a valuable hardwood, is the dominant species. Like its neighbouring hill regions, Tripura has many wild animals, including elephants, tigers, wild boar, wild buffalo, and the world's largest ox, the *gaur.*

Climate. During the monsoon season, June to September, most of Tripura receives more than 200 centimetres of rain. Annual totals can reach more than 250 centimetres. Temperatures in the mountains do not rise as high as they do in the valleys.

Facts in brief about Tripura

Population: *1991 census*—2,744,827.
Area: 10,486 km².
Capital: Agartala.
Chief products: *Agriculture*—cotton, jute, rice, tea, timber.

History. The early history of the Tripura region is lost in legend. The name Tripura appears on pillars of the emperor Asoka, who ruled India in the 200's B.C.

In the 1300's, Tripura came under the control of the Manikya dynasty, a family of Indo-Mongolian origin. Under the Manikya rulers, the political influence of Tripura extended over Assam, Bengal, and Burma. In the 1600's, the Mughal emperors came to rule much of Tripura. But the local Manikya kings, or *maharajahs,* still retained some of their power. In the late 1700's, the parts of Tripura that had been ruled by the Mughals came under British control. As part of the colonial province of eastern Bengal and Assam, Tripura was known as Hill Tippera.

During the 1800's and 1900's, two Manikya maharajahs stood out as fine rulers of Tripura. Birchandra Manikya Bahadur (ruled 1862-1896), an accomplished poet and musician as well as a politician, sought to modernize the state by reorganizing its administration and abolishing slavery and *suttee* (see **Suttee**). Bir Bikram Kishore Manikya Bahadur (ruled 1923-1947) continued the effort at modernization with a project to improve educational development in the arts and sciences, agriculture, medicine, and technology. Maharajah Bir Bikram also opened the airport at Agartala and established a college in the eastern part of the city. The college still bears its founder's name.

Following the death of Bir Bikram in 1947, Tripura prepared to become part of an independent India. It entered the Indian Union in October 1949 and became a union territory in 1956. Tripura became a state of the republic of India in 1972. The two influential political parties in Tripura are Congress (I) and the Communist Party of India (Marxist).

Triticale is a grain produced by crossbreeding wheat and rye. It has a high nutritional content because it contains more usable protein than either wheat or rye. The plant stands from 45 to 105 centimetres tall and has 6 to 10 long, narrow leaves. The head consists of many spikelets, each of which holds three to five kernels of grain.

Botanists first crossbred wheat and rye in 1876. This process yielded a hybrid plant that could not produce seeds. In 1937, scientists discovered that treating seedlings of wheat-rye crosses with a chemical called *colchicine* made the plants fertile.

The first triticale breeding programme was set up in Sweden in the mid-1930's. By the 1950's, many countries had such programmes. These programmes have developed many varieties of the grain. Someday, triticale may become an important food in countries not suited for wheat production. Some varieties can grow in cold climates and in sandy or acid soils. Others resist rust better than wheat does and produce a higher yield than rye. At higher latitudes, yields of triticale grain increase at a greater rate than do wheat yields.

Triticale will probably be used in many countries mainly as an animal feed. It can also serve as a pasture crop. Food companies may use triticale to make flour for bread and cakes. Other potential uses for the grain include cereal products and beermaking.

Scientific classification. Triticale is a member of the grass family, Gramineae (Poaceae). It makes up the genus *Triticosecale.*

Tritium is a hydrogen isotope used in the release of nuclear energy through fusion, as in the hydrogen bomb. It is three times as heavy as ordinary hydrogen. The name *tritium* comes from the Latin *tri,* meaning *three.* Tritium decays to form helium; half the tritium disintegrates in about 12 years.

See also **Hydrogen; Nuclear weapon.**

Triton was a sea god in Greek mythology. He was a *merman,* a creature often portrayed with the body of a man from the waist up and a fish from the waist down. Triton lived with his parents, the sea god Poseidon and his wife, Amphitrite, in their golden palace at the bottom of the sea. Triton often blew his conch shell horn to stir up or calm the seas and rivers.

According to early myths, Triton often befriended passing sailors. He guided the Argonauts, companions of the Greek hero Jason, and gave one of them a clod of earth that later became the island of Thera in the Aegean Sea. In later myths, Triton appeared as a menacing sea monster. The Roman poet Virgil told how Triton drowned Misenus, a human trumpeter who challenged his skill on the conch shell. In some Greek myths, members of a group of minor sea gods who served Poseidon were called Tritons.

See also **Poseidon.**

Triumph, in ancient Rome, was the highest honour given to a victorious general. The word *triumph* probably came through the Etruscan language from *thriambos,* a Greek word that means a procession honouring the god Bacchus.

When a victor received a triumph, he entered Rome in a triumphal chariot drawn by four horses, and proceeded along the *Via Sacra* (Sacred Way) to the capitol. The senators walked at the head of the procession. Behind them came trumpeters, carriages bearing the spoils of war, oxen to be sacrificed, and captives in chains. Then came the general, crowned with laurel, and his children and friends. The general's soldiers were at the end of the procession, cheering and singing as they marched. In a triumph given to honour a naval commander, nautical trophies were carried.

Under the Empire, only the emperor could receive a triumph. A great general might receive a minor celebration called an *ovation.*

Triumph, Arch of. See **Arc de Triomphe.**

Triumvirate. In Roman history, a triumvirate was a group of three men who seized control of the government. Rome had two triumvirates. The first was formed in 60 B.C. It was made up of Julius Caesar, Pompey the Great, and Marcus Licinius Crassus. The second triumvirate was formed in 43 B.C., after Brutus and Cassius had murdered Julius Caesar. Its members were Octavian (Augustus), Marcus Lepidus, and Mark Antony.

The Roman republican form of government almost disappeared while the triumvirates lasted. Both triumvirates ended in civil war to determine the supremacy of one member of the group. In the first war, Caesar defeated Pompey the Great. In the second civil war, Mark Antony was overcome by Octavian, who became Emperor Augustus.

See also **Antony, Mark; Augustus; Caesar, Julius; Crassus, Marcus Licinius; Pompey the Great.**

Trogons are brightly coloured birds that live in warm areas. The female has duller colours on the head and back.

Trogon is a family of birds. Trogons live in warm regions of both the Eastern and the Western hemispheres. Dark blue, green, or violet feathers that shine like metal cover the head and back of most kinds of male trogons. Their underparts are red, orange, or yellow. Females resemble males but have duller colours on the head and back. The trogon has a short, strong bill. Two of its toes point forward and two backward. Its feet are small and weak. The female lays two to four white, pale blue, or pale green eggs. The nestlings have no feathers when hatched. African and Asian trogons feed mostly on insects. American trogons eat fruit and insects. See also **Quetzal.**

Scientific classification. Trogons make up the trogon family, Trogonidae. The collared trogon is *Trogon collaris.*

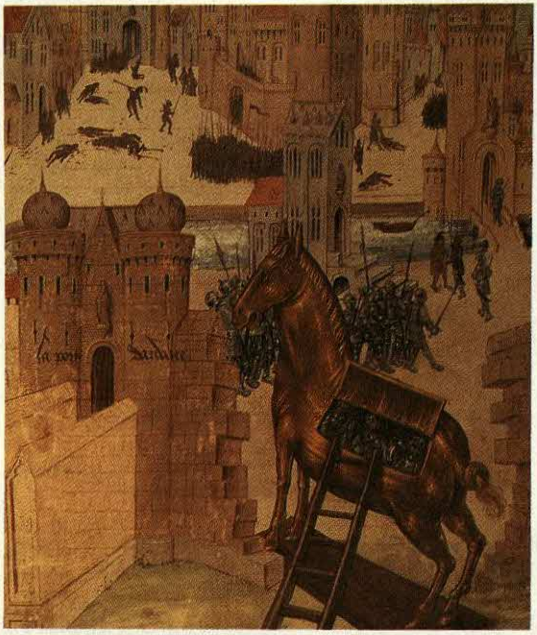
Troika is a Russian word that means *a group of three.* A light, Russian sleigh that is pulled by three horses is called a troika. The term *troika* was applied to a 1960 plan by the Soviet Union to have the United Nations headed by three secretaries-general instead of one. See also **Cold War** (The troika proposal).

Trojan horse. See **Trojan War; Mythology** (picture).

Trojan War was a conflict in which ancient Greece defeated the city of Troy. The legend of the war inspired many leading works of classical literature. Some of the events that occurred during and after the Trojan War became the subject of three great epic poems—the *Iliad* and the *Odyssey,* attributed to the Greek poet Homer, and the *Aeneid* by the Roman poet Virgil. The heroes and victims of the war were portrayed in such Greek tragedies as *Agamemnon* by Aeschylus, *Ajax* by Sophocles, and *The Trojan Women* by Euripides.

Scholars do not agree about the truth behind the legend of the Trojan War. Some of them believe it distorts and exaggerates small conflicts involving the Greeks from about 1500 to 1200 B.C. Others think the legend is based on one great war, which most say probably took place during the mid-1200's B.C. The Homeric epics combine historical material of different times with fictional material. As a result, the works are not reliable historical documents. But archaeologists have found historical evidence in the ruins of Troy and other places that confirms certain events described in the epics.

The beginning of the war. According to ancient Greek myths, the Trojan War resulted from an incident



The Trojan Horse, Recueil, by Raoul Lefevre; Bibliotheque Nationale, Paris

The Trojan War, according to legend, was finally won by the Greeks, who hid inside a wooden horse to enter the city of Troy.

at the wedding feast of Peleus, the king of Phthia, and Thetis, a sea goddess. All the gods and goddesses of Mount Olympus had been invited except Eris, the goddess of discord. Eris was offended and tried to stir up trouble among the guests at the feast. She sent a golden apple inscribed "For the most beautiful." Three goddesses—Hera, Athena, and Aphrodite—each claimed the apple, and a quarrel began. Paris, the son of King Priam of Troy, judged the dispute. He awarded the apple to Aphrodite because she had promised him Helen, the most beautiful woman in the world.

Helen was already married to King Menelaus of Sparta. But when Paris visited her, she fled with him to Troy. Menelaus and his brother, Agamemnon, organized a large Greek expedition against Troy to win Helen back. The Greek army included such heroes as Achilles, Ajax the Greater, Nestor, and Odysseus (Ulysses in Latin).

The siege of Troy. The Greek army laid siege to Troy for 10 years but could not conquer the city. The *Iliad* describes some of the events that occurred during the last year of the struggle. The war began to go badly for the Greeks after Achilles, their bravest warrior, left the battlefield. Achilles refused to fight because Agamemnon, the Greek commander, had insulted him. The Trojans, led by Hector, drove the Greeks back to their ships. Achilles finally returned to combat after his best friend, Patroclus, had been slain by Hector. Achilles killed Hector to avenge Patroclus' death.

The *Iliad* ends with Hector's funeral, and Greek legends relate events that followed. According to these legends, the Trojans received help from their allies, the Ethiopians and an army of women warriors called Amazons. But Achilles enabled the Greeks to defeat their enemies by killing Penthesilea, the queen of the Amazons, and Memnon, the king of the Ethiopians. Paris, aided by the god Apollo, later shot Achilles in the heel with an arrow and killed him.

The fall of Troy is described in the *Aeneid.* The Greeks built a huge wooden horse, which has become known as the *Trojan horse,* and placed it outside the walls of Troy. Odysseus and other warriors hid inside the horse while the rest of the Greek army sailed away.

The prophetess Cassandra and the priest Laocoön warned the Trojans against taking the horse into their city. But Sinon, a Greek prisoner, persuaded them that the horse was sacred and would bring the protection of the gods. The Trojans then pulled the horse into Troy. That night they fell asleep after celebrating their apparent victory. Odysseus and his companions then crept out of the horse and opened the city gates for the rest of their warriors, who had returned from a nearby island.

The Greeks took back Helen, slaughtered almost all the Trojans, and burned Troy. According to the *Aeneid,* the few Trojan survivors included the warrior Aeneas, whose descendants founded Rome.

Related articles in ***World Book*** include:

Achilles
Aeneas
Aeneid
Agamemnon
Ajax the Greater
Ajax the Lesser
Cassandra
Hector
Helen of Troy
Iliad
Laocoön
Menelaus
Odyssey
Paris
Priam
Troy
Ulysses

Troll. See Fairy.

Trolley. See Electric railway; Tram and trolleybus.

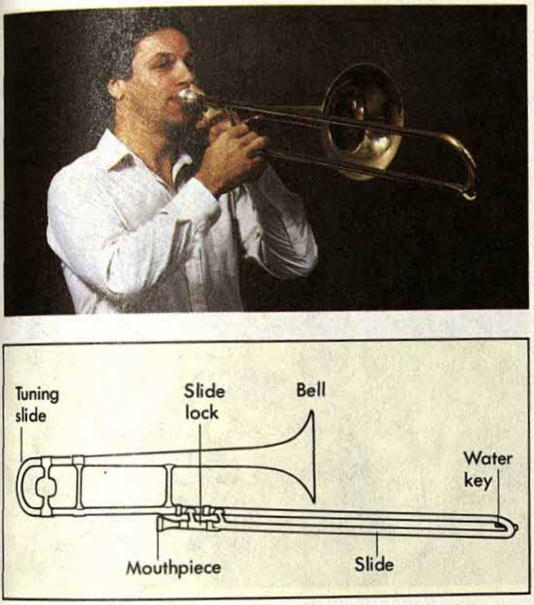
Trollope, Anthony (1815-1882), was a popular English novelist of the 1800's. He was over 30 years old when he published his first book. But after he started, he wrote with such regularity that his novels and tales fill more than 50 volumes.

Trollope's most famous books are the "Barsetshire Novels." These six stories about life in the imaginary county of Barsetshire, and especially the cathedral city of Barchester, are mildly satirical. But their tone shows Trollope's affectionate tolerance for the weaknesses of his basically generous and well-meaning characters. Trollope had so clear an idea of his creation that he could draw a map of Barsetshire.

The Barsetshire novels are *The Warden* (1855), *Barchester Towers* (1857), *Doctor Thorne* (1858), *Framley Parsonage* (1861), *The Small House at Allington* (1864), and *The Last Chronicle of Barset* (1867). Trollope's other works include social satire novels, such as *The Bertrams* (1859) and *The Way We Live Now* (1875); political novels, such as *The Eustace Diamonds* (1873); and novels of psychological analysis, such as *Cousin Henry* (1879).

Trollope was born in London. In his autobiography, he described his unhappy childhood. His family was poor, and his education was often interrupted by lack of money. Frances Trollope, Anthony's mother, was also a writer. She wrote *Domestic Manners of the Americans* (1832). The Trollopes moved to Bruges, Belgium, to escape their creditors. All his life, Trollope remembered the humiliation of those early years.

Trollope returned to London in 1834. He became a clerk in the post office, where he worked for many years. He designed the red pillar boxes that are still used for posting letters in the United Kingdom. His last years were happy. He died in London of a stroke brought on, it is said, by over-hearty laughter.



The trombone is an important brass instrument in both popular and classical music. It has a long slide attached to a tube. A musician plays different notes by moving the slide.

Trombone is a brass instrument that consists chiefly of an oblong tube expanded into a bell at one end. It is played by blowing into a cup-shaped mouthpiece and vibrating the lips. Most trombones have a long slide. The player changes tones by tightening the lips and by moving the slide back and forth. A *valve trombone* has three valves instead of a slide. The *tenor trombone* is the most popular type of trombone. The *bass trombone* is larger. It has, in addition to the slide, one or two rotary valves for extending the range downward.

A primitive type of trombone, called a *sackbut,* was used as early as 1495 in England. The instrument developed and by the 1700's its name had changed to *trombone.* The trombone became a part of symphony orchestras during the 1800's. Today, the instrument is popular in concert, marching, and military bands, and in popular music and jazz.

Trona is one of the most important natural soda minerals. It consists of sodium carbonate, sodium bicarbonate, and water and has the chemical formula $Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$. Trona is the main source of soda ash, which is used in the manufacture of chemicals, glass, and paper. Trona is grey or yellowish-white and forms fibrous crystals. It dissolves easily in water, and so it is found at the earth's surface in solid form only in dry regions. Trona also occurs underground and is extracted from *brine* (extremely salty water).

Trondheim (pop. 134,654) is the third largest city in Norway. It lies on the southern shore of Trondheims Fiord, where the Nid River empties into the fiord (see **Norway** [map]).

Trondheim is an important export centre for copper and iron ores, pyrites, wood pulp, timber, and fish. The city was founded in A.D. 998 by King Olav I. The Nidaros Cathedral, one of the finest Norman Gothic buildings in the world, dates back to A.D. 1070. The modern Technical University of Norway is also in Trondheim.

Trooping the colour, in British regiments, is part of the ceremony of mounting guard. The best-known trooping the colour ceremony takes place each year on Horse Guards Parade, London, on a Saturday early in June. It celebrates the British sovereign's official birthday. The ceremony in its present form dates from 1805.

The Household Brigade performs the ceremony in the presence of the sovereign, as colonel in chief. The *colour* (flag) of a different regiment is trooped each year, and the sovereign wears the uniform of that regiment. The guards are drawn up along two sides of a square. The massed bands of the brigade form on the south side of the parade ground. A sergeant bears the colour, accompanied by two guards. The colour is placed in front of the parade. This part of the ceremony is *lodging the colour.* The guards salute the sovereign, and the sovereign inspects the parade. During the *trooping,* which follows, the new guard takes over. See also **Royal Family of the United Kingdom** (picture).

Tropic bird. See **Tropicbird.**

Tropic of Cancer is an imaginary line that traces the northern boundary of the earth's Tropical Zone. It marks the farthest limit north of the equator where the sun can appear directly overhead. The line lies 23° 27′ north of the equator. The vertical rays of the sun shine down on the Tropic of Cancer at noon on the day of the summer solstice, which is June 20 or 21. The position of the Tropic of Cancer is determined by the inclination of the earth's axis to the plane of the earth's orbit around the sun.

The Tropic of Cancer passes through many lands with a variety of climates. It crosses Mexico, passes between Florida and Cuba, and crosses the Sahara, Arabia, north-central India, and southern China. It crosses the Pacific Ocean immediately north of the main islands of Hawaii (see **World** [map]). The word *Cancer* means *crab* in Latin, and refers to a constellation of the zodiac. The position of the Tropic of Cancer on the map was first marked by its location directly below the constellation of Cancer. To an observer on the Tropic of Cancer, the North Star appears at an angle of 23° 27′ above the horizon.

See also **Tropics.**

Tropic of Capricorn is an imaginary line that traces the southern boundary of the earth's Tropical Zone. It marks the farthest limit south of the equator where the sun can appear directly overhead. The Tropic of Capricorn lies 23° 27′ south of the equator. The vertical rays of the sun shine on the Tropic of Capricorn at noon on the day of the winter solstice, which is December 21 or 22.

The Tropic of Capricorn crosses northern Chile and Argentina, Paraguay, and southern Brazil in South America. In Africa, it crosses Namibia, Botswana, South Africa, Mozambique, and Madagascar. The Tropic of Capricorn also passes through the middle of Australia (see **World** [map]). The Tropic of Capricorn separates the southern tropics from the South Temperate Belt. The word *Capricorn* comes from the Latin *caper,* meaning *goat,* and *cornu,* meaning *horn.* It refers to a group of stars representing the sign of the zodiac known as Capricorn. The Tropic of Capricorn used to lie directly below this constellation.

See also **Tropics.**

Tropical fish. Many kinds of fish live in the freshwater and saltwater habitats of the tropics. However, the term *tropical fish* is applied particularly to small, brightly coloured varieties that breed very rapidly and are popular for home aquariums. Tropical fish are often a little smaller than goldfish, but tropical fish usually range in size from about 2.5 to 30 centimetres. About 600 different kinds of tropical fish are kept in home aquariums. Even new owners of a home aquarium can keep many kinds of fish.

Most tropical fish will eat food made from grain, dried shrimp, fish, insects, and aquatic plants. Such food can be purchased in any pet shop. Small pieces of shrimp, oyster, crab, canned fish, boiled fish, and other kinds of fish may also be given. Many tropical fish are *carnivores* (meat-eaters), but sometimes plant-eating fish can be trained to eat such food. Some "hard-to-keep" saltwater fish require special foods, such as sponges and live coral, but many species eat a wide variety of foods. Some people raise small worms to feed their pet fish. A good rule is to feed only the amount that the fish will clean up promptly because uneaten food drops to the bottom of the aquarium and decays. This makes the water foul and may kill the fish.

A tropical fish aquarium should be covered with a flat pane of glass to control the temperature. This also keeps the fish from leaping out of the aquarium. Water plants should be grown because they keep the water in better condition and produce oxygen for the fish to breathe.

The most common and best-known tropical fish is the *guppy.* It comes from fresh waters of the West Indies and South America. The female guppy is about 4 centimetres long, and the male is even smaller. The female is grey, but the male is brilliantly rainbow-hued. Guppies breed when they are about 3 months old and bear their young alive. Each female guppy produces from 20 to 50 young. See **Guppy**.

Other popular, freshwater tropical fish that bear live young are the *swordtail,* the *platy,* and the *black molly.* Some tropical fish that bear their young in eggs are the *barbs, danios, rasboras, characins,* and *cichlids.* The various *labyrinth fishes* are so named because they have a cavity with many branches in their head, usually above the gills. The fish store air in this cavity and use it as an accessory breathing organ. Some saltwater fish, such as *clownfish* and some *damsels,* have been successfully bred and raised in home aquariums.

Scientific classification. Most live-bearing, freshwater tropical fish belong to the live-bearer family, Poeciliidae. The guppy is *Poeciliidae reticulata.*

See also **Fish** (pictures: Fish of coral reefs; Fish of tropical fresh waters); **Angelfish; Fightingfish; Aquarium.**

Tropical fruit. See **Fruit** (How horticulturists classify fruit).

Tropical plant. See **Tropical rainforest.**

Tropical rainforest is a forest of tall trees in a region of year-round warmth and plentiful rainfall. Almost all such forests lie near the equator. They occupy large regions in Africa, Asia, and Central and South America, and on Pacific islands. The largest tropical rainforest is the Amazon rainforest, also called the *selva.* It covers about a third of South America. Tropical rainforests stay green throughout the year.

Squirrel monkeys live only in the tropical rainforests of Central and South America. These monkeys scamper along tree branches and climbing vines.

A tropical rainforest has more kinds of trees than any other area in the world. Scientists have counted 179 species in one 1-hectare area in South America. Most northern temperate forests have fewer than seven species. About half of the world's species of plants and animals also live in tropical rainforests. More species of amphibians, birds, insects, mammals, and reptiles live in tropical rainforests than anywhere else.

The tallest trees of a rainforest may grow as tall as 60 metres. The *crowns* (tops) of other trees form a covering of leaves about 30 to 45 metres above the ground. This covering is called the *upper canopy.* The crowns of smaller trees form one or two *lower canopies.* All the canopies shade the forest floor so that it receives less than 1 per cent as much sunlight as does the upper canopy.

Most areas of the forest floor receive so little light that few bushes or herbs can grow there. As a result, a person can easily walk through most parts of a tropical rainforest. Areas of dense growth called *jungles* occur within a tropical rainforest in areas where much sunlight reaches the ground. Most jungles grow near broad rivers or in former clearings. See **Jungle.**

The temperature in a rainforest rarely rises above about 35° C or drops below about 20° C. In many cases, the average temperature of the hottest month is only 1° to 3° C higher than the average temperature of the coldest month.

At least 200 centimetres of rain falls yearly in a tropical rainforest. Thundershowers may occur on more than 200 days a year. The air beneath the lower canopy is almost always humid. The trees themselves give off water through the pores of their leaves. This process, called *transpiration,* may account for as much as half of the rain in the Amazon rainforest.

All tropical rainforests resemble one another. But each of the three largest ones—the American, the African, and the Asian—has a different group of animal and plant species. For instance, each rainforest has many species of monkeys, all of which differ from the species of the other two rainforests. In addition, different areas of the same rainforest may have different species. For example, many kinds of trees that grow in the mountains of the Amazon rainforest do not grow in the lowlands of that forest. For illustrations of rainforests, see **Plant** (Where plants live) and **Tree** (Trees around the world). For illustrations of some of the animals that live in rainforests, see **Animal** (Animals of the tropical forests).

Plant life. A tropical rainforest is always green. Most trees in the forest lose old leaves and grow new ones throughout the year. But certain species of trees may lose all of their leaves for a short time during the year. Different kinds of trees bear flowers and fruit at different times of the year. Thus, some kind of tree is in bloom or in fruit at any time of the year. Some short trees bear fruit on the trunk or on large, low branches. Some tall trees bear large fruit on long, drooping, ropelike stalks.

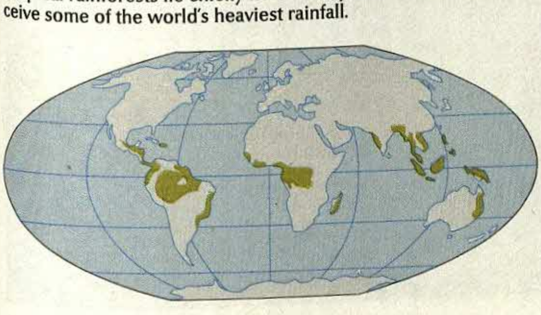
Tropical rainforest trees include some species of great beauty and others that provide fruit, timber, and other useful products. Cassias, dhaks, shellseeds, and tabebuias bear bright-coloured flowers. But most rainforest trees have smaller, less noticeable flowers, and the canopy always appears mostly green. Brazil nuts, cashews, durians, mangosteens, sapodillas, and many kinds of figs and palms yield fruit. Valuable timber comes from balsas, brazilwoods, lauans, logwoods, mahoganies, and rosewoods. Kapoks bear fruit that contains a fluffy fibre used to stuff life jackets and upholstery. Cinchonas provide the drug quinine. Curare, another important drug, comes from various woody vines that grow in a tropical rainforest.

In a tropical rainforest, many plants grow on tree branches, where they receive more sunlight than they would on the ground. Such plants, called *epiphytes* or *air plants,* include ferns, mosses, orchids, and bromeliads. Climbing plants called *lianas* twine around tree trunks and branches. Some lianas form loops and knots as they grow toward the sunlight. See **Epiphyte.**

Several kinds of *strangler* trees grow in rainforests. These trees start life as air plants. But unlike other species of air plants, they develop roots that reach down to the ground. The roots surround the tree on which the strangler lives. In time, the strangler may kill the other tree by depriving it of food, light, and water.

Tropical rainforests

Tropical rainforests lie chiefly near the equator. These areas receive some of the world's heaviest rainfall.



Huge growths called *buttresses* extend from the trunk to the roots of many trees in tropical rainforests. The buttresses may help support the trees. Yagua Indians hunt small birds with blowguns in the upper Amazon Valley of South America.

In a tropical rainforest, most plant *nutrients* (the chemicals necessary for growth) are locked up in the living vegetation. Small amounts of nutrients are stored in a thin layer of soil near the surface, where decaying vegetation mixes with the soil. The roots of most rainforest trees remain close to the supply of nutrients near the surface. In some species, the roots form large growths called *buttresses* that extend between the roots and the trunk. The buttresses may help keep the trees upright.

A tropical rainforest has no dominant species of trees. Most kinds of trees are widely scattered throughout the forest and depend on animals for pollination. By contrast, in nontropical forests, certain tree species dominate and pollination occurs chiefly by wind.

Animal life. A great variety of animals live in a tropical rainforest. Many of these animals spend their lives in the trees and never descend to the ground. The fruit and nuts of the upper and lower canopy furnish food for bats, gibbons, monkeys, squirrels, parrots, and toucans. Sloths and some monkeys feed on the leaves. Hummingbirds and sunbirds sip nectar from flowers. Frogs, lizards, and snakes also dwell among the branches. Large birds and large snakes prey on the smaller animals.

Many canopy animals are especially suited to treetop life. Flying lemurs and flying squirrels glide from tree to tree. Galagos and marmosets jump from branch to branch. Several kinds of anteaters, monkeys, opossums, and porcupines sometimes hang by their tail.

Antelope, deer, pigs, tapirs, and many kinds of rodents roam the forest floor. They feed on roots, seeds, and leaves, and also on fruit that drops to the ground. Chimpanzees, coatis, and several members of the cat family live on the floor and in the trees. Ants may be found at all levels in a rainforest. Bees, butterflies, mosquitoes, moths, termites, and spiders are also abundant.

People and the rainforests. Over the years, few people have dwelt in tropical rainforests. Most such people clear small areas and plant crops there. They chop down the trees, burn them, and plant seeds among the ashes. But after a few years, the thin layer of soil no longer provides good harvests. The farmers then move elsewhere and begin the process all over again. Such farming, called *slash-and-burn cultivation,* can support only a small population.

A few groups of rainforest people practise no agriculture. For example, the Pygmies of the Central African rainforest live by hunting wild animals, gathering wild plants, and trading with agricultural tribes.

Today, the rapid growth of the world population and the increasing demands for natural resources threaten many tropical rainforests. People have destroyed large areas of rainforests by clearing land for farms and cities. Huge mining, ranching, and timber projects also have caused much damage. Scientists estimate that from 5.5 million to 22 million hectares of tropical rainforests are destroyed yearly. They fear that further forest destruction will lead to the elimination of the local peoples, and hundreds of thousands of species of plants and animals.

See also the sections on plant and animal life in the articles on **Africa, Asia, North America,** and **South America.**

Tropicbird is any of three species of sea birds found in tropical regions. Tropicbirds eat fish, which they catch by diving down into the water from the air.

Tropicbirds' feathers are mainly white. They have two extremely long, slender middle tailfeathers. The *red-billed tropicbird* lives in tropical parts of the Atlantic, Indian, and Pacific oceans. It has a coral-red bill, black wing tips, and many black bars across its back. The bird is nearly 1 metre long, including its middle tailfeathers, which measure about 60 centimetres. Other kinds of tropicbirds are the *white-tailed* and the *red-tailed.*

Tropicbirds nest in holes, in cracks in rocks, or on sand. On land, a tropicbird shuffles along on its breast with outstretched wings because it cannot stand.

Tropicbirds are robbed by frigatebirds, which swoop down on them when they return from feeding and force them to disgorge their catch of fish.

Scientific classification. Tropicbirds make up the family Phaethontidae. The red-billed tropicbird is *Phaethon aethereus;* the white-tailed is *P. lepturus;* and the red-tailed is *P. rubricauda.*

See also **Bird** (picture: Sea birds and birds of the Antarctic).

Tropics are the regions of the earth that lie within about 2,570 kilometres north and 2,570 kilometres south of the equator. Two imaginary lines, the Tropic of Cancer and the Tropic of Capricorn, form the boundaries of the tropics. The Tropic of Cancer is 23° 27′ north of the equator, and the Tropic of Capricorn is 23° 27′ south of the equator. These lines mark the northernmost and southernmost places on the earth where the sun ever shines directly overhead.

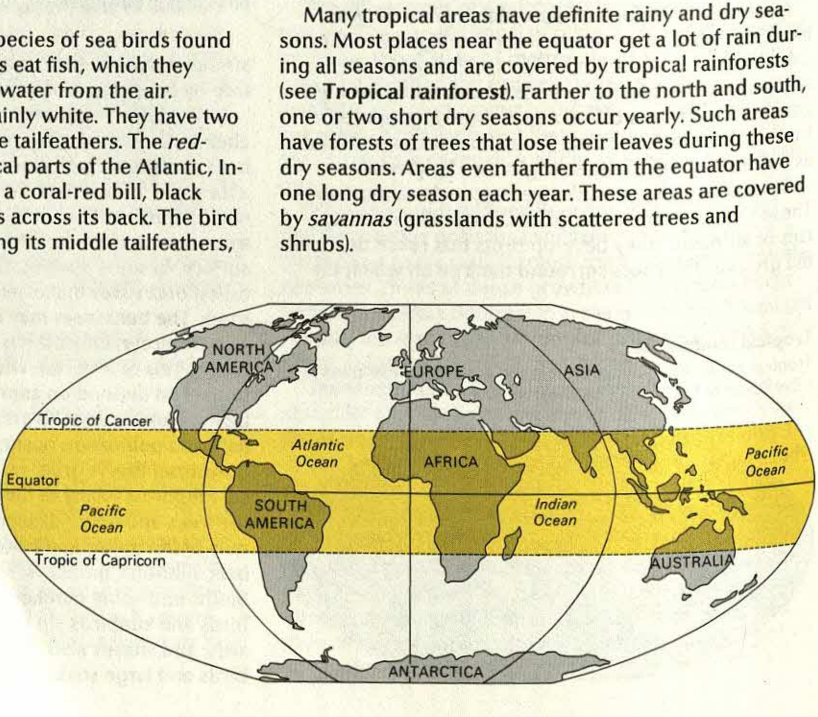
Most places in the tropics have warm to hot temperatures throughout the year. Tropical places near sea level are hot because every day the sun's rays shine almost straight down at noon. Such direct rays produce higher temperatures than do slanted rays.

The temperature does not change much in the tropics because the amount of daylight differs little from season to season. At the equator, the sun shines about 12 hours a day. At the edges of the tropics, daylight ranges from about $10\frac{1}{2}$ hours a day in winter to about $13\frac{1}{2}$ hours a day in summer. Places at the edges of the tropics have cool periods in winter. Tropical places at high altitudes are cooler than tropical places near sea level because the temperature drops about 2° C per 300 metres of elevation.

Many tropical areas have definite rainy and dry seasons. Most places near the equator get a lot of rain during all seasons and are covered by tropical rainforests (see **Tropical rainforest**). Farther to the north and south, one or two short dry seasons occur yearly. Such areas have forests of trees that lose their leaves during these dry seasons. Areas even farther from the equator have one long dry season each year. These areas are covered by *savannas* (grasslands with scattered trees and shrubs).

The tropics

The tropics, shown on the map on the right, lie on both sides of the equator. They are bounded by two imaginary lines called the Tropic of Cancer and the Tropic of Capricorn. Most tropical places are warm to hot throughout the year.



For information on how people live in the tropics, see Africa (Ways of life south of the Sahara); **Asia** (Way of life in Southeast Asia); **Indian, American** (Indians of the tropical forest); **Latin America** (Way of life). See also Fish (pictures); **Jungle; Savanna; Tropic of Cancer; Tropic of Capricorn.**

Tropism is a bending movement in living things caused by an outside *stimulus* (signal). For example, sunlight causes plant leaves and stems to bend toward it. A tropism results from differences in the growth rate of various parts of an *organ* (a body structure) when the stimulus is present. The bending usually is slow. For example, some tropisms in plants take from one hour to several days for completion. They occur only in young tissues.

Tropisms are named after the stimulus that causes them. For example, *geotropism* is bending caused by gravity, *phototropism* is bending caused by light, and *hydrotropism* is bending caused by moisture. Tropisms may be *positive* (bending toward the stimulus) or *negative* (bending away from the stimulus). Studies of tropisms led to the discovery of *auxins,* the plant hormones that control growth (see **Auxin**).

Troposphere is the layer of the atmosphere closest to the earth. We live there, and nearly all the earth's weather occurs there. The upper boundary of the troposphere is the *tropopause.* The height of the tropopause varies. The tropopause lies about 16 kilometres over the equator and about 10 kilometres over the North and South poles. The *stratosphere* lies above the tropopause, followed by the *mesosphere* and the *thermosphere.*

Within the troposphere, the temperature of the air generally decreases as the altitude increases. The temperature of the troposphere also varies with latitude. The temperature averages about 15° C near the earth's surface and drops to about −65° C at 16 kilometres above the surface. At the equator, the tropopause can become as cold as −80° C. Above the tropopause, the temperature stops decreasing with altitude.

The temperature decrease at higher altitudes in the troposphere plays an important part in changes in the weather. Air in the troposphere can mix because cold, *dense* (heavy) air lies above warmer, less dense air. If the air starts moving upward, it continues to rise because it remains warmer and less dense than its surroundings. Sinking air remains colder than its surroundings and continues to sink. These tropospheric mixings are the major weather systems which affect the earth. Rising air will form clouds and rain, and sinking air will bring fair weather.

The troposphere helps maintain the earth's climate and helps keep the earth warm. Most sunlight passes through the troposphere to heat the earth's surface. This heat energy then radiates from the surface and escapes into space. But some energy is trapped by tropospheric gases—mainly water vapour and carbon dioxide—and by clouds. This trapping of heat energy is called the *greenhouse effect* (see **Greenhouse effect**).

See also **Air; Mesosphere; Stratosphere; Thermosphere.**

Trossachs is a beautiful wooded gorge in Scotland's Central Region near Ben A'an and Ben Venue. Loch Katrine lies at the western end of the gorge and Loch Achray, at the eastern end. Sir Walter Scott made the Trossachs famous in his poem "The Lady of the Lake."

See also **Central Region.**

Trotsky, Leon (1879-1940), also spelled *Trotzky,* was a leader of the Bolshevik revolution in Russia (see **Bolsheviks**). While Lenin lived, Trotsky was the second most powerful man in Russia. After Lenin's death, Trotsky lost the leadership to Joseph Stalin. Trotsky was later exiled. Until his death, Trotsky waged a bitter fight against Stalin from abroad. See **Lenin, V. I.; Stalin, Joseph.**

The area around the Trossachs, in Scotland's Central Region, is known for its beautiful scenery. It is a popular country area for walking.

Leon Trotsky

Trotsky was born Lev Davidovich Bronstein in Ukraine, of well-to-do parents. After two years of revolutionary activity as a Social Democrat, he was arrested in 1898. He escaped from Siberian exile in 1902 and went to London, where he met Lenin. He returned to Russia to take an active part in the revolution in 1905.

Trotsky was jailed for his leadership in the Saint Petersburg Soviet of 1905. But he escaped in 1907. For 10 years he was a revolutionary writer and editor in western Europe. During World War I, he was expelled from France and Spain, and went to New York, where he received the news of the czar's downfall in 1917. He returned to Russia. With Lenin, he successfully plotted the seizure of power that brought about a Bolshevik government in November 1917 (October on the old Russian calendar). Trotsky became the first Soviet commissar of foreign affairs, and was soon the commissar of war.

In the civil war of 1918-1920, Trotsky was an efficient organizer of the triumphant Red army. After Lenin's death, many believed that Trotsky would be the new head of the Soviet government, but he was outsmarted by Stalin. Trotsky was expelled from the Communist Party in 1927, and the next year was exiled to Soviet Central Asia. He was deported to Turkey in 1929. He later moved to Norway and then to Mexico.

By 1940, Stalin apparently regretted his "leniency" with Trotsky. Stalin's secret police sent an agent to Mexico, and Trotsky was murdered there. Trotsky died on Aug. 21, 1940. See also **Union of Soviet Socialist Republics** (The October Revolution).

Trotting, also called *harness racing,* is a popular form of horse racing. In trotting, each horse pulls a driver in a light, two-wheeled vehicle called a *sulky.* Trotting is popular in Australia, Canada, New Zealand, the United States, and most European countries. Millions of racegoers attend trotting races yearly. Many races are held at major race tracks, where people can bet on the horses.

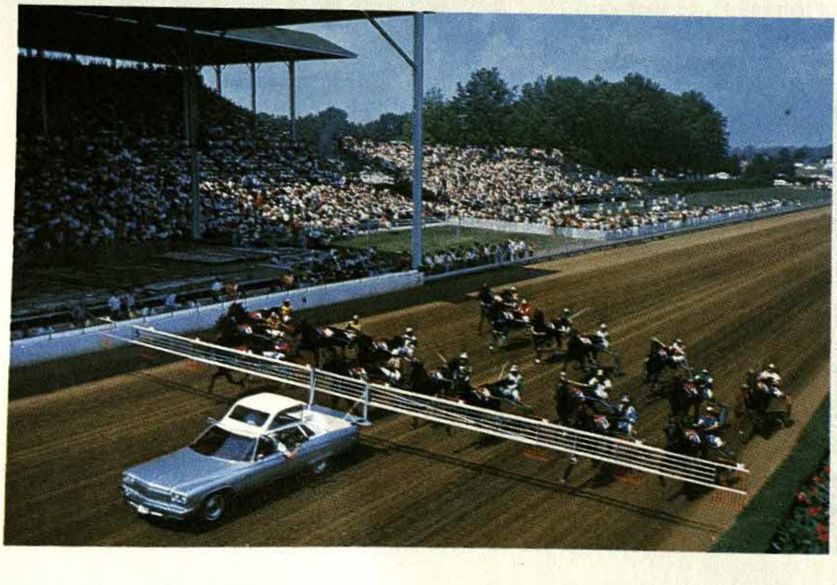
There are two kinds of trotting horses—*trotters* and *pacers.* A trotter moves the front leg on one side of its body and the hind leg on the other side at the same time. A pacer moves the legs on the same side of its body together. About 80 per cent of the trotting horses in the United States are pacers. In most European countries, only trotters race. The two types of trotting horses rarely race together because pacers generally go faster than trotters.

Trotting horses are *standardbreds,* a breed that developed from thoroughbreds. The first thoroughbred to produce great trotters was Messenger. This horse was brought to the United States from England in 1788. One of Messenger's descendants, Hambletonian, is known as the "great father" of trotting horses. Hambletonian was born in 1849 and sired 1,331 horses before his death in 1876. Almost all the standardbred horses in the United States can still be traced to him. The annual Hambletonian Stakes, the most famous trotting event, is named after him.

Drivers. In some countries, both amateur drivers and professional drivers may compete in trotting races.

The race. Trotting races are held on an oval track. The track ranges from 0.8 kilometre to 1.6 kilometres long. The standard distance of a trotting race is 1.6 kilometres. In some races, a horse must finish first in two out of three *heats* (parts of a race) to win the race.

Before a trotting race begins, the horses and drivers line up behind a specially designed car called a *mobile starting gate.* This vehicle has two collapsible arms that keep the horses in line. The horses follow the starting gate as it moves around the track. The gate—and the horses—gradually gain speed. The race starts one or two seconds after the gate pulls away, when the horses pass the starting line and break an electronic beam. The arms of the gate fold inward. The starting gate then speeds ahead of the horses and moves to one side of the track. The horses race around the track to the finish-



A trotting race begins after the drivers line up their horses behind a specially designed car called a *mobile starting gate.* The gate has two arms that keep the horses in line. After the horses reach the starting line, the arms fold up and the car moves off the track.

ing line. Any horse that changes from the pace or trot to another gait must be moved to the outside of the track. It must regain the correct gait before rejoining the field.

People bet on horses to finish first, second, or third in a trotting race.

History. Various forms of trotting races have been held since ancient times. Modern trotting developed in the United States. It probably began in the 1700's. In 1806, people in New York started to record trotting speeds. That year, a trotter named Yankey became the first trotting horse to race a mile (1.6 kilometres) in less than 3 minutes.

During the 1800's, trotting became extremely popular in the United States. Only trotters competed in races until the 1860's, when pacers were introduced.

Interest in trotting racing declined in the United States in the early 1900's after cars began to replace horses as the most common means of transportation. But the sport again grew popular in the 1940's, after pari-mutuel betting and night races were introduced. The mobile starting gate was adopted for racing in 1946 (see **Horse racing** [Betting]).

In 1988, the pacer Matt's Scooter became the fastest horse in trotting-racing history by pacing a mile (1.6 kilometres) in 1 minute $48\frac{2}{5}$ seconds during a time trial. The fastest time recorded during a race is 1 minute $50\frac{1}{5}$ seconds by the pacer Ramblin Storm, also in 1988.

Troubadour was one of a large group of poet-musicians who flourished in southern France in the 1100's and 1200's. The word comes from the Latin *tropare* (to compose). Many scholars believe the troubadours may have modelled their lyric verse on the works of Spanish Arab poets and classical Roman poets such as Ovid.

Troubadours composed poetry in a Romance language called Provençal, or *langue d'oc.* The *canso d'amor* (love song) was one of the rich and varied poetic forms used by troubadours. In the *canso,* the poet imagines the lady of his desires as the model of virtue, and dedicates his talents to singing her praises. The troubadours' praise of physical love stood in direct contrast to traditional Christian morality. Their ideal of love and their praise of women influenced many writers, including Dante and Petrarch.

See also **Knights and knighthood** (Knighthood in literature); **Minnesinger; Storytelling** (The Middle Ages); **Trouvère.**

Trout is a fish closely related to salmon, whitefish, and chars. Trout are native to cool waters of the Northern Hemisphere and have been introduced to cool waters throughout the world. Most *species* (kinds) of trout spend their entire lives in freshwater streams and lakes. Some species migrate to the sea to feed and grow and return to fresh water to *spawn* (lay eggs). Trout are prized both as sport fish and as food fish.

Kinds of trout

All trout have strong teeth and streamlined bodies with small scales. True trout have a small, fleshy fin called an *adipose fin* that grows on the back, near the tail fin.

There are three kinds of true trout—the brown trout, the rainbow trout, and the cutthroat trout. The *brown trout,* or *river trout,* is native to Europe and western Asia. It occurs in several different forms. The coastal form is known as *sea trout* or *salmon trout* and a common still-water form is called *lake trout.* The brown trout has been introduced to many other regions. The brown trout's body has dark brown or black spots, many of which are surrounded by pale halos.

The *rainbow trout* and *cutthroat trout* are native to the Pacific northwest region of North America. The rainbow trout resembles the brown trout in shape, but has a wide purplish band along its side, which, with the shiny green scales above and below, gives a rainbow effect. Like the brown trout, it has a coastal form and a river form. The coastal form, which feeds and grows in coastal waters, is known as the *American steelhead.* The mountain river form is called the *American rainbow trout.* The rainbow trout has been introduced to other countries, especially in Europe. It tolerates higher water temperatures than the brown trout and also takes a wider variety of food. These qualities make the rainbow trout ideal for fish farms, from which it often escapes into the wild.

The cutthroat trout is a nonmigratory species. It takes its name from the bright red colour of its throat. It is sometimes introduced to European fish farms and occasionally forms *hybrids* (cross breeds) with the rainbow trout.

In North America, two other species of fish are known as trout. These are the brook trout and the lake trout. They are both close relatives of the European or arctic char. All three species thrive in cold water. The *brook trout* lives in streams in eastern North America and along the North Atlantic coast. The brook trout has been introduced to cold streams in parts of Europe, and the lake trout is established in several Alpine lakes in Switzerland. In Europe, the brook trout forms hybrids with brown trout and introduced rainbow trout. The hybrids are striped and known as *tiger* or *zebra trout.* The *lake trout* is the largest species of trout. It lives in lakes along the U.S.-Canadian border region and southern Hudson Bay area.

The *European char* is found in coastal areas of the northern Arctic seas and in nearby river systems. It also lives in cold, clear lakes in Britain, Ireland, Scandinavia, and the northern Soviet Union.

The life of a trout

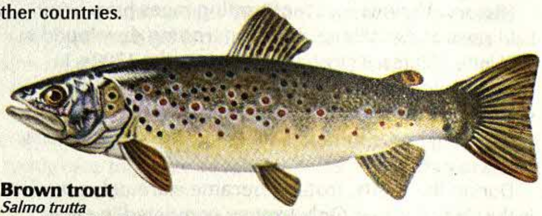
Most trout spawn in streams or rivers, but some spawn in lakes with gravel bottoms and good water flow. Trout spawn in spring or autumn depending on the species.

The spawning behaviour of rainbow trout is typical of that of other trout species. In early spring, rainbow trout move upstream to a spawning area. The female chooses a suitable site, usually a shallow, gravel area at the beginning of a stretch of choppy water. There, the female turns on her side and beats her tail up and down, scooping out a shallow nest called a *redd.* After the redd is prepared, the female positions herself over it. The male courts her by swimming closely alongside her and quivering his body. When the female is ready to spawn, she moves to the bottom of the redd and presses her belly against the gravel. The male positions himself close to her. As the female releases eggs, the male releases sperm that fertilize the eggs.

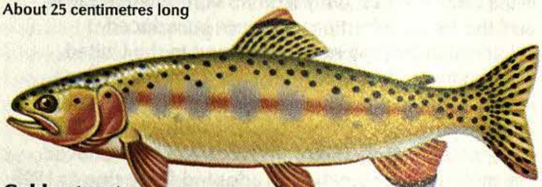
Some kinds of trout

True trout

All true trout, also known as black-spotted trout, have dark markings on a light background. The rainbow trout, *below,* originally lived only in the waters of the western half of North America, but has been introduced into many other countries.



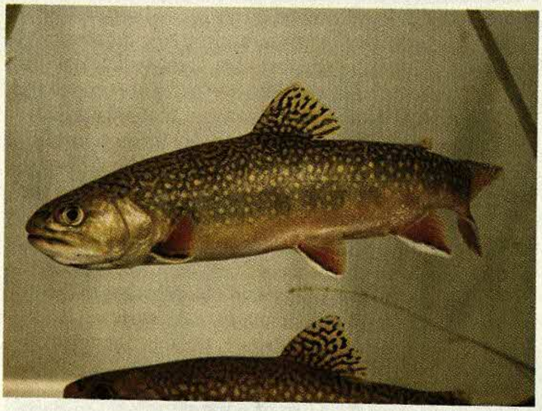
Brown trout
Salmo trutta
About 25 centimetres long

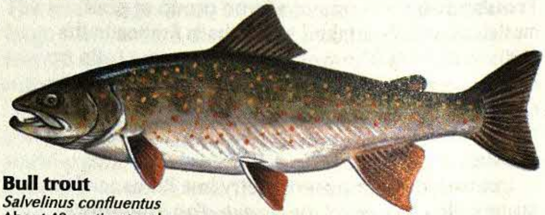


Golden trout
Salmo aguabonita
About 25 centimetres long

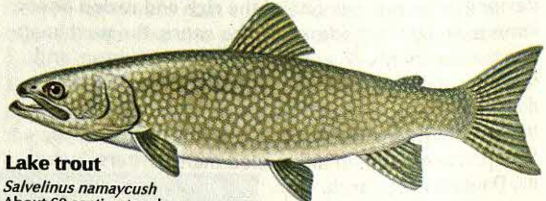
Other trout

Other trout are distinguished from true trout by their light red, pink, or cream-coloured spots. These fish include the brook trout, *below,* a traditional favourite of anglers; the bull trout, *top right;* and the lake trout, *bottom right.*





Bull trout
Salvelinus confluentus
About 40 centimetres long



Lake trout
Salvelinus namaycush
About 60 centimetres long

After the eggs have been fertilized, the female covers them with gravel. The eggs usually hatch in about 2 months. After the young hatch, they move up through the gravel into the water.

Young trout eat mainly *invertebrates* (animals without backbones), including insects. Mature trout also feed on other fish and on crayfish. They may eat young birds, lizards, or other animals that fall into the water. The life span of trout varies among species. Rainbow trout live up to 11 years and lake trout up to at least 25 years.

Trout fishing

All trout species are valued as sport fish. The rainbow trout and the cutthroat trout are especially prized because of their fighting ability and their spectacular leaps when hooked. The brook trout, another spirited fighter, also is a favourite among fishing enthusiasts. Lake trout are usually taken by *trolling* (trailing a line behind a boat) or by dropping a line through the ice in winter. Some trout species are important commercially as food. Commercial fishing crews catch great numbers of lake trout and steelhead trout. Rainbow trout and brook trout are raised in fish farms and sold for food.

Scientific classification. The brown trout is *Salmo trutta;* the rainbow trout is *S. gairdneri;* the cutthroat trout is *S. clarki.* The brook trout is *Salvelinus fontinalis;* the lake trout is *S. namaycush;* the European or arctic char is *S. alpinus.*

See also **Fish** (Pictures: A leaping trout; Fish of temperate fresh waters; How a fish develops; How fish reproduce).

Trouvère was one type of a group of lyric poets who flourished in northern France in the 1100's and 1200's. The word comes from an Old French word meaning *to compose.* The Trouvères composed their poems in an Old French dialect, called *langue d'oïl.* They were strongly influenced by the style and subject matter of the troubadours of southern France. Like the troubadours, the trouvères wrote *chansons d'amor* (love songs). See also **Troubadour.**

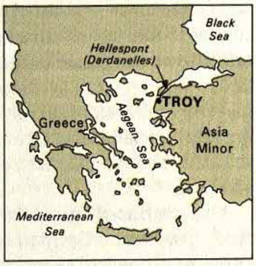
Trovatore, Il. See **Opera** (*Trovatore, Il*); **Verdi, Giuseppe.**

Troy, also called Ilium, was an ancient city in Asia Minor (now Turkey) that was made famous in the legends of early Greece. The *Iliad* and the *Odyssey,* epics attributed to the Greek poet Homer, and the *Aeneid,* an epic written by the Roman poet Virgil, tell a story about Troy that is probably only partly true. The city's two names come from Ilus, its legendary founder, and Tros, the father of Ilus.

The legendary Troy was a mighty city ruled by King Priam. The king's son Paris judged a beauty contest between the goddesses Hera, Athena, and Aphrodite. He chose Aphrodite as the winner because she promised to give him the most beautiful woman in the world as his wife. Soon after the contest, Paris visited Menelaus, the king of Sparta. Paris fell in love with Menelaus' wife, Helen, who was known as the most beautiful woman in the world. Paris took Helen to Troy, and thereby angered Menelaus.

The people of the mainland of Greece, called *Achaeans* by Homer, swore revenge on Paris and the people of Troy. The Greeks sent a great naval expedition to Troy. The expedition was led by Agamemnon, Menelaus' brother, and included Achilles, Odysseus (Ulysses in Latin), and many other Greek heroes.

The Greeks besieged Troy for 10 years. But they could not capture the city, which was protected by high stone walls. Finally, Odysseus ordered workers to build a huge wooden horse, in which some Greek soldiers hid. The rest of the Greeks then pretended to sail away, leaving the horse standing outside the city walls.



Troy was an ancient city in Asia Minor. Ruins of Troy have yielded historical relics nearly 5,000 years old.

The curious Trojans dragged the wooden horse inside the city, though Laocoön, a Trojan priest, warned them not to do so. That night, the Greek soldiers crept out of the horse, opened the city gates, and let the rest of the Greek forces into Troy. The Greeks massacred the people of Troy and looted and burned the city. Only Aeneas, the hero of Virgil's *Aeneid,* and a few other Trojans escaped. Paris was killed in the war, and Helen returned to Menelaus.

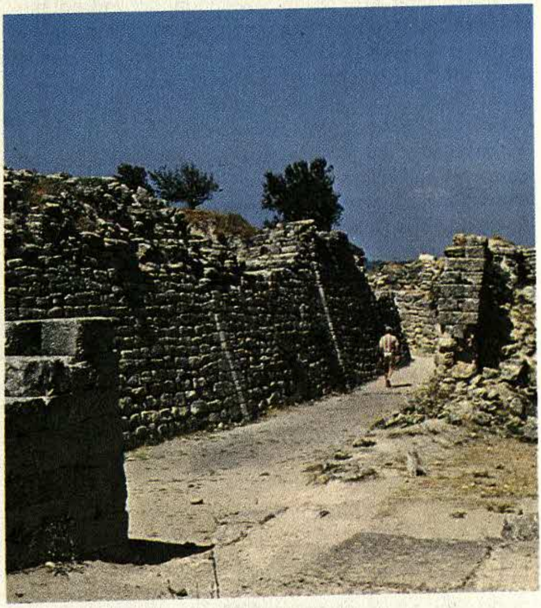
The real Troy. Apart from the legends, little is known about the history of Troy. Archaeologists have learned that Troy was founded in the early Bronze Age, which began about 3000 B.C. in Asia Minor. The city stood on a high point of a fertile plain in what is now northwestern Turkey. It was near the southern end of the *Hellespont,* a strait now called the Dardanelles. Archaeologists have discovered that nine cities were built on the site of Troy. Each successive city was built on the ruins of the one before it.

The second Troy and the sixth one were especially wealthy cities. The Trojans farmed, bred and raised horses, herded sheep, and produced woollen goods. They traded with the Mycenaeans, who lived in Greece, and with other people who lived along the Aegean coast of Asia Minor.

Scholars know little about the actual Trojan War. Archaeologists have found evidence that the Greeks may

Detail of *The Burning of Troy* (early 1600's), an oil painting on canvas by an unknown French artist; Blois Museum, France

The fall of Troy was made famous in legends. Greek soldiers hid in a huge wooden horse, and curious Trojans dragged it into the city. The Greeks later crept out and attacked Troy.



The site of Troy has the remains of nine successive cities. The stone walls above are from Troy VI, destroyed by an earthquake in about 1300 B.C. It was probably not the Troy of legend.

have attacked and destroyed Troy in a great expedition similar to the one described in the *Iliad.* However, no one knows the cause of the war. Greek scholars believed that Troy fell in about 1184 B.C. Many archaeologists think that the seventh city on the site of Troy was the one written about in ancient Greek literature. These scholars believe that the city was destroyed in about 1250 B.C.

The archaeological Troy. The first archaeologist to study Troy was a German named Heinrich Schliemann. Other persons had noted that a small mound about 6 kilometres from the Dardanelles seemed to fit the geographical location of Troy described in the *Iliad.* The mound was called *Hissarlik.* Schliemann began digging there in 1870. He found evidence that several cities had been built on the site over a long period. Near the bottom of the excavation, he discovered the ruins of an ancient city with massive walls, well-built houses, and hidden treasures of gold and silver. Schliemann mistakenly believed this city, which he called Troy II, was the Troy described by Homer.

The German archaeologist Wilhelm Dörpfeld, who had assisted Schliemann, conducted further excavations at Troy in the 1890's. He was the first researcher to recognize that nine cities had stood on the site. Dörpfeld believed the sixth was the city of Homer's *Iliad.* This city, called Troy VI, was larger than the earlier ones and was protected by high walls. The houses were large and rectangular and were probably built around a central palace.

In 1932, Carl Blegen, an American scholar from the University of Cincinnati, Ohio, U.S.A., began a new research expedition at Troy. His study lasted six years and confirmed the findings of Dörpfeld, except that Blegen believed the seventh city was the legendary Troy. According to Blegen, Troy VI represented a major stage in the development of the city, even though it was not the Troy of Greek legends. This stage was marked by the arrival of immigrants who shared many cultural characteristics with the Mycenaeans in Greece. Troy VI was destroyed by an earthquake in about 1300 B.C. The next city, which archaeologists called Troy VIIa, had small, crude houses that were crowded together. The city was less prosperous than the earlier Troys. Around 1250 B.C., Troy VIIa was looted and burned. Although Blegen believed that Troy VIIa was the legendary city, archaeologists have not been able to prove that it was.

From about 1100 B.C. to 700 B.C., no one lived on the site of Troy. Some Greek settlers then established a small village there in about 700 B.C. The last city on the site, Troy IX, was built in the late 300's B.C. It was called Ilium by the Greeks and Romans. Ilium lasted about 700 years. It was abandoned in about A.D. 400, and remained undisturbed until Schliemann discovered it.

See also **Trojan War** and its list of *Related articles;* **Homer; Schliemann, Heinrich.**

Troy weight is a standard system used in weighing gold, silver, platinum, and coins. It is also used to weigh jewels, except pearls and diamonds, which are weighed in carats. The name *Troy* comes from *Troyes,* a French town. In the 1300's, Troyes had its own system of weights and measures. In the system of troy weight, the pound contains 12 ounces. The ounce equals 20 pennyweights, and the pennyweight equals 24 grains. The troy pound and the apothecaries' pound both contain 5,760 grains. The pound avoirdupois equals 7,000 grains. The grains in all three systems are equal. The troy pound equals 0.3732 kilogram.

See also **Pennyweight; Weights and measures; Apothecaries' weight; Avoirdupois.**

Truce is a short suspension of hostilities between opposing sides in a war. A truce may be called to allow each side to remove wounded from the battlefield, bury the dead, exchange prisoners, or observe a religious holiday. A truce may also be used for brief negotiations. In such cases, the negotiations are usually conducted under a white *flag of truce,* which indicates the peaceful intentions of the participants.

During the early 1000's, Christian clergy of France instituted a custom called the Truce of God. This custom prohibited warfare on weekends and during certain religious observances. Opponents often ignored the truce.

A truce is different from an *armistice.* An armistice is an agreement to stop fighting that covers a longer period of time than a truce. It may even bring a permanent end of the fighting. Often, an armistice leads to a peace treaty that provides a political settlement of the war. The fighting in World War I (1914-1918) ended with an armistice followed by peace treaties. In the Korean War, truce talks were held from July 1951 to July 1953, when an armistice was signed and the fighting stopped. However, negotiations following the armistice failed to result in a final political settlement. Thus, the armistice did not lead to a peace treaty. In January 1973, a cease-fire agreement occurred during the Vietnam War. But it failed to lead to a peace treaty, and the war continued until 1975.

See also **Flag of truce; Peace** (The Middle Ages).

Trucial states. See **United Arab Emirates.**

Truck is a motor vehicle used to carry freight. Trucks can carry almost every kind of cargo. They bring food and other goods to shops and homes. They take raw materials from one factory to another. They carry packaged goods such as cartons of food, or bulk materials such as fuel oil for petrol stations. They also perform most other tasks in the community that need large vehicles. Trucks help to transport almost everything we eat, wear, and use in our home, school, or working life.

Some trucks, especially smaller ones with enclosed bodies, are often called *vans.* In the United Kingdom and some other countries, another word for truck is *lorry.* But the American term *truck* is gradually being adopted in most English-speaking countries.

Trucks vary widely in size. Some trucks are no bigger than cars, and the majority can carry no more than a few metric tons of cargo. But some are designed to transport heavy loads over long distances, and may take cargoes of 30 metric tons or more. Such trucks may weigh over 50 metric tons, including the load. There are special trucks that can take even heavier loads.

No one knows exactly how many trucks there are in the world, but the figure is probably more than 100 million. Over 12 million new trucks are built each year.

Kinds of truck. Small trucks and vans often have the same engines and gearboxes as similar-sized cars. Bigger trucks are of far more rugged construction and have much more powerful engines than cars. Car engines seldom exceed 200 horsepower (hp), but heavy truck engines range from 200 to more than 400 hp. More important, their *torque* (pulling power) may be up to ten times greater.

Almost all trucks have a cab or driving compartment at the front, with a load space behind. Sometimes, the cab and load space is combined on a single base frame, or *chassis*. Such a vehicle is often called a *rigid* truck. Most small and medium-sized trucks are of this kind, and there are also bigger examples with three, four, or more axles. Trucks with more than two axles are sometimes called *multi-wheelers*.

For heavier loads, the driver's cab and the engine components are often built into a self-contained vehicle called a *tractor unit*, or *truck-tractor*. This vehicle hauls a detachable trailer called a *semi-trailer* which contains the cargo. The trailer has wheels at the back only. The front rests on a swivelling coupling or turntable at the back of the tractor. This arrangement helps to distribute the weight evenly between the two. The combined vehicle or *rig* is often called a *tractor-trailer* outfit, or an *articulated* (jointed in the middle) outfit.

Rigid trucks can also pull trailers, but their trailers are self-supporting, and are simply towed behind the truck. Such combinations are sometimes called *drawbar-trailer* outfits or *roadtrains*. In some countries, such as Australia, where trucks have very large distances to cover, both articulated outfits and roadtrains are allowed to pull more than one trailer at a time.

Driving trucks. In many ways trucks are like cars to drive, but there are important differences. The heaviest trucks usually have at least 8 gears, and some have as many as 20 forward gears, with several reverse gears as well. These gears enable the truck to make the most efficient use of its engine power on different gradients and surfaces. Some truck makers, such as Scania of Sweden, have developed computerized systems to help with gear selection. Fully-automatic gearboxes are still rare on heavy trucks, but are sometimes used on vehicles such as refuse trucks that have to stop and start frequently.

Truck brakes are powerful and sensitive, and are usually air-assisted. Some trucks have *retarders* to help them slow down without wearing out the brakes. This is especially useful in mountainous countries. Many trucks have *antiskid systems* on the wheels to help them brake safely on slippery surfaces. To help spread the weight they carry, most trucks have double wheels on all axles except the front.

Most medium and heavy trucks, as well as increasing numbers of light trucks, are now powered by diesel fuel. Diesel trucks can cover a greater distance per litre of fuel than petrol-powered trucks. Diesel engines are generally more reliable than petrol engines, although they tend to cost more to buy and maintain. Because of worries about the rising cost of fuel, many manufacturers have fitted trucks with streamlined wind deflectors and other fuel-saving aerodynamic devices. They are also developing engines that are more fuel-efficient.

Trucks in industry. Trucks have made it easier to assemble or manufacture products in factories far from the places where the raw materials come from. Trucks can carry in raw materials, and other trucks distribute the finished goods throughout a country, or in other countries. The raw materials may be brought by truck from other factories, from ports and railway terminals, or from organizations such as farms and livestock producers. In the United States, trucks haul about 75 per cent of industrial products, and in the United Kingdom the figure is closer to 80 per cent.

Trucks may carry standard international *containers*. These are big boxes 12 metres long or more. The containers are packed with cargo, and can easily be transferred from one vehicle to another. They can be carried by trains, ships, and canal barges as well as trucks.

Sometimes trucks travel on ferries, especially on busy sea routes such as those between the United Kingdom and Europe. In some parts of the world, especially Europe and North America, semi-trailers or even complete trucks are carried over long distances by rail on special *piggyback* trains. This saves time and fuel.

Trucks in public service. Trucks are used for many jobs that need specialist vehicles bigger than cars. Examples of such specialist vehicles are: a mail van, street-cleaning vehicle, a refuse collection vehicle, a mobile library or shop, a gantry truck for maintaining street lighting, an ambulance, a prison van, a fire-fighting vehicle, an outside broadcast unit for television or radio, a police incident room or control centre, a breakdown truck or tow truck, or a mobile home. As long as a truck chassis is strong and powerful enough, specialist companies can convert it for almost any use.

Trucks are also used extensively for military purposes. Often, the armed services buy exactly the same trucks as civilian truck operators, but they may demand specially strengthened models for more arduous conditions. A typical military requirement is for *four-wheel drive*, which means power is transmitted to both front and rear wheels. This gives improved traction on rough terrain. Such vehicles are also used by organizations such as electricity and telephone companies for maintaining their overland cables.

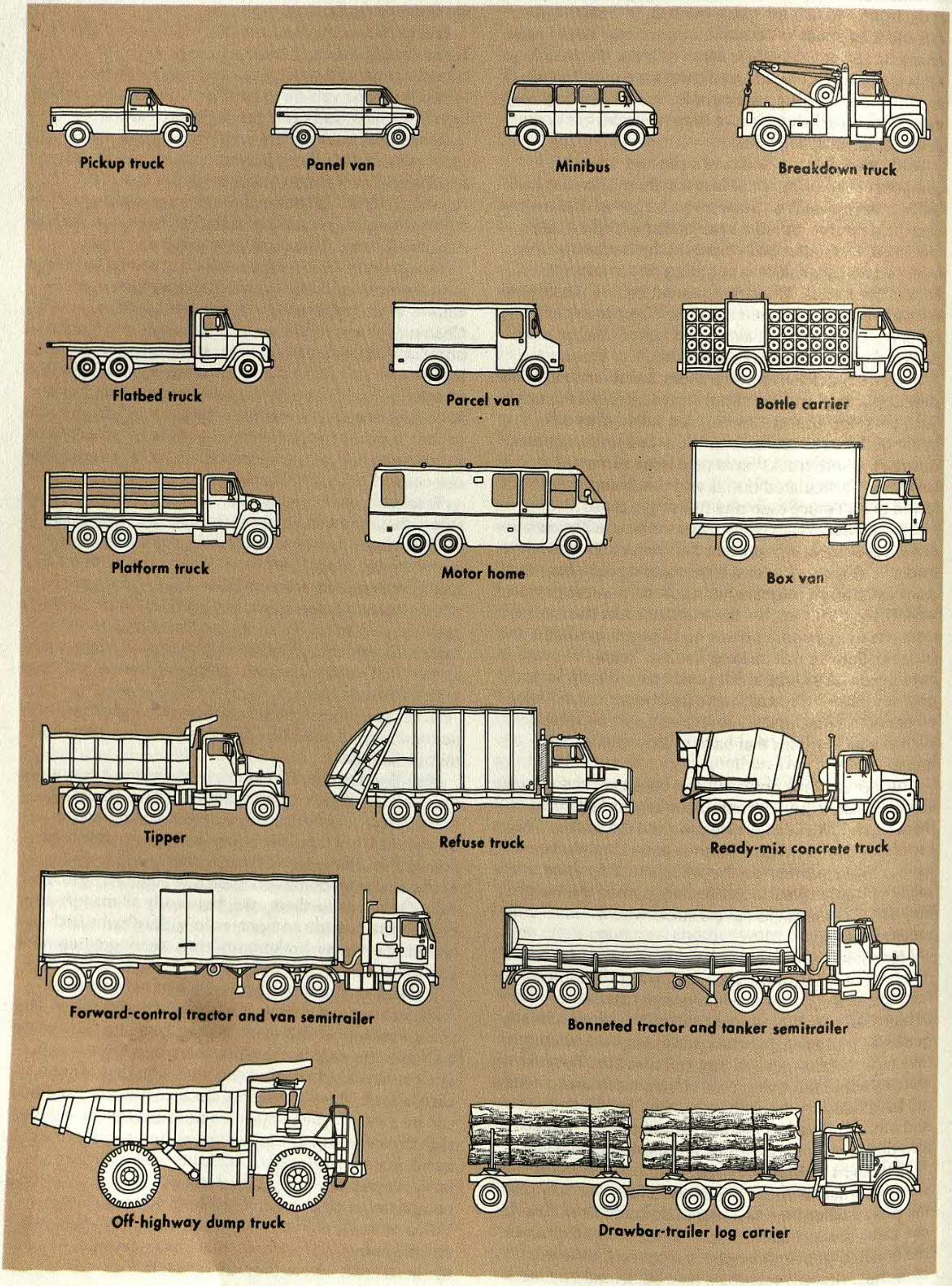
Very special truck frames, some with many axles, are needed for giant mobile cranes, tank transporters, and missile launchers.

Building trucks. Trucks are made from an enormous number of separate components, or parts. The truck manufacturers produce some of these components themselves, but they buy others from many specialist companies. There is a vast truck industry all over the world. Some truck makers even buy engines, axles, and cabs. Others make their own, but nearly all manufacturers still use outside companies to supply items such as electrical systems, braking systems, steering equipment, and tyres.

Unlike cars, most trucks are built by two separate manufacturers—a chassis maker and a bodybuilder. The *chassis maker*, whose name is usually on the front of the truck, fits the engine, gearbox, axles, and driver's cab. The result is a vehicle that can be driven, but cannot carry a load. The *bodybuilder* finishes the job. The body can be a simple flat platform, a box van (with or without side doors), an open-topped tipper body or dump truck, a tanker, a concrete mixer, or another kind of special body. Most truck chassis are built by large multinational companies such as Mercedes-Benz of Germany and Volvo of Sweden. However, truck bodies are generally still made by smaller companies in the country, or even the local area, where they are based in use.

Some kinds of trucks

Thousands of kinds of trucks perform specialized work. They range from small pickup trucks that carry relatively light loads to huge drawbar-trailer log carriers with tremendous hauling power. Some have the cab over the engine.



Pickup truck
Panel van
Minibus
Breakdown truck
Flatbed truck
Parcel van
Bottle carrier
Platform truck
Motor home
Box van
Tipper
Refuse truck
Ready-mix concrete truck
Forward-control tractor and van semitrailer
Bonneted tractor and tanker semitrailer
Off-highway dump truck
Drawbar-trailer log carrier

Two main truck types are exceptions, in that both are built entirely by the chassis-maker. One is the *articulated tractor unit.* The other is the *panel van,* or *parcel van,* and the closely-related *open pickup.*

Some bodies can be removed from one truck chassis and transferred to another one or on to a railway wagon. These *swap-bodies* or *demountable bodies* are similar to standard containers but are usually smaller. Often, they have folding legs so that they can be left standing at truck height, and be picked up without needing a separate crane. With this system, a truck can be out working, while spare bodies are being loaded. In the early 1990's, there were nearly half a million of these swap-bodies in Europe alone.

Trucks and the law. In most countries, operating trucks is strictly controlled by law. Laws regulating trucks vary considerably from one country to another, but the truck operator is almost always required to have some form of permit or licence. To gain a licence, an operator must have a knowledge of transport, and the financial ability to operate and maintain the trucks properly. In some countries, one of the managers of a truck company may have to pass an examination.

Most countries apply very strict safety standards to trucks. Such regulations are usually much stricter than similar standards for private cars. In the UK, for example, trucks must pass a tough government-run test every year. For cars, such tests are not needed until they are at least three years old. Critical mechanical features such as braking, tyres, and steering are tested especially severely.

Trucks are usually subject to strict size and weight limits, laid down by law. For any given truck size, there are limits on individual axle weight, and also on the *gross weight* of the vehicle (its weight when loaded). These weight limits vary from country to country. They tend to be higher in areas, such as parts of Australia, where trucks need to cover vast distances. In Europe, the maximum weight for most normal road-going trucks ranges from 38 to 50 metric tons, and is generally around 40 metric tons. The maximum permissible laden weight for a single axle is usually between 10 and 13 metric tons, and less on the front axle.

Truck drivers usually have to take a special driving test, and they are often restricted to driving for a limited number of hours each day. In the UK and in some other countries, most trucks are required to have a *tachograph* (an instrument which automatically records daily driving activities). Other rules govern the transport and handling of hazardous goods such as chemicals.

History. Trucks have been used for almost as long as cars. Trucks were being manufactured in many countries by 1900. Important figures in truck development were the German motor vehicle pioneers Gottlieb Daimler and Karl Benz. Their companies combined to form the Mercedes-Benz company, Europe's largest producer of heavy trucks. Early trucks were often powered by steam engines, and were very heavy and slow. Their solid tyres, simple suspension, and open cabs made them uncomfortable to drive.

In the early 1900's, most long-distance freight was still carried by rail. During World War I (1914-1918), the versatility of trucks became clear. Trucks were widely used for war work. After the war, old wartime trucks were used in many countries by people setting up trucking companies. World War II (1939-1945) gave trucking a similar boost. During the postwar period, better, wider roads were being built in many countries. Trucks became bigger, faster, and could compete more effectively with trains.

The first trucks tended to have the cab behind the engine. This arrangement is still common for light trucks such as pickups, and in some countries it is used even for the heaviest trucks. The arrangement makes the engine easier to reach for service, and is often favoured in countries where sophisticated maintenance facilities are not always available. Such vehicles are sometimes known as *normal control trucks, bonneted trucks,* or *conventionals.* To comply with strict limits on truck lengths, however, many manufacturers have developed *forward control* or *cab-over* trucks. In this arrangement the driver sits directly above the engine, leaving more space behind for freight.

See also **Car** with its list of *Related articles.*

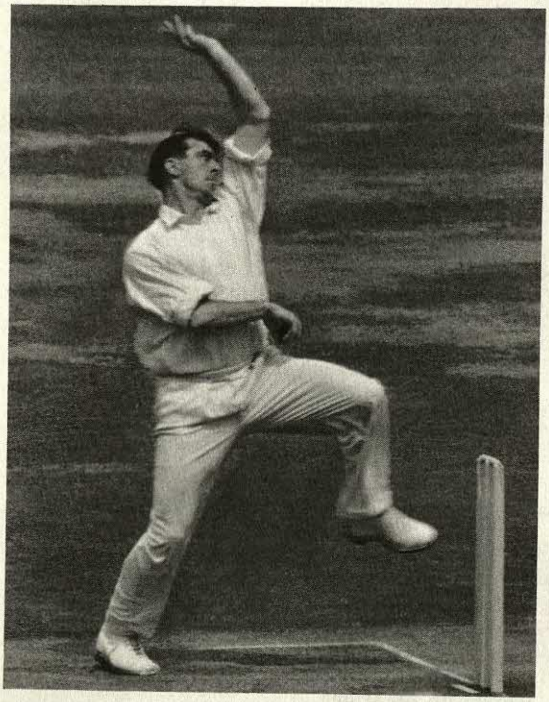
Trudeau, Edward Livingston (1848-1915), was a famous pioneer in the antituberculosis movement in the United States. Trudeau himself contracted the disease at the age of 25. He became convinced of the need for adequate sanatoriums, and established the Adirondack Cottage Sanitarium at Saranac Lake, New York, U.S.A. It later became the Trudeau Sanitarium, which achieved a worldwide reputation.

Trudeau also founded the Saranac Laboratory in 1894, the first U.S. tuberculosis research laboratory. The sanatorium was closed in 1957 because of the great strides made in antituberculosis therapy. Trudeau was born in New York City. He studied medicine at Columbia College (now Columbia University), New York City.

Trudeau, Pierre Elliott (1919-), was prime minister of Canada from 1968 to 1979 and from 1980 to 1984. A member of the Liberal Party, he tried to ease the long-strained relations between English- and French-speaking Canadians. Trudeau also worked to broaden Canada's contacts with other nations. He tried to strengthen Canada's independence in world affairs and expanded Canada's relations with China and the Soviet Union. Trudeau achieved a major national goal in 1982, when the Canadian constitution came under complete Canadian control. Previously, constitutional amendments required the British Parliament's approval.

Trudeau won reelection in 1972 and 1974 but was defeated in 1979. He regained power after he led the Liberals to victory in a general election in 1980. A recession struck Canada in the early 1980's, and Trudeau lost some public support for his economic policies. He resigned as prime minister on June 30, 1984.

Joseph Philippe Pierre Yves Elliott Trudeau was born into a French-Canadian family in Montreal on Oct. 18, 1919. He earned a law degree from the University of Montreal in 1943 and a master's degree in political economy from Harvard University in the United States in 1945. Trudeau was elected to Canada's House of Commons in 1965. Under Prime Minister Lester B. Pearson, Trudeau served first as parliamentary secretary and then as minister of justice and attorney general. Trudeau had only three years of experience in public office. In 1968, after Pearson's retirement, Trudeau was elected leader of the Liberal Party and prime minister.



Freddie Trueman's technique as a fast bowler earned him the nickname of "Fiery Fred."

Trueman, Freddie (1931-), a cricketer for Yorkshire, England, became one of the world's greatest opening fast bowlers. In March 1963, he broke the world record of 242 wickets in test cricket. His best achievement was 7 for 44 against the West Indies in 1963, with a total of 12 for 119 in the match. In 1964, he became the first bowler ever to take 300 test wickets. Frederick Sewards Trueman was born at Stainton, South Yorkshire. He played in his first test match in 1952. He later became a sports journalist and radio commentator.

Truffaut, François (1932-1984), was a leading French film director. He directed several partly autobiographical films, beginning in 1959 with *The 400 Blows.* The character Antoine Doinel reflects Truffaut's almost delinquent youth. Truffaut continued the story in *Stolen Kisses* (1968) and *Bed and Board* (1971). Truffaut's *Day for Night* won the 1973 Academy Award as best foreign language film.

Truffaut began his career in the 1950's as a film critic and developed a deep respect for American suspense and action films. His *Shoot the Piano Player* (1960) resembles an American gangster film. Two other Truffaut films, *The Bride Wore Black* (1967) and *Mississippi Mermaid* (1969), show the influence of the American director Alfred Hitchcock. Truffaut was born in Paris. His other major films include *Jules and Jim* (1961) and *The Wild Child* (1970). He also directed a film in English, *Fahrenheit 451* (1966).

Truffle is a fungus that is used as a food and a flavouring. Truffles grow on or near the roots of trees, usually oaks. Most truffles are found from 8 to 30 centimetres below ground. They range from 0.6 to 10 centimetres in diameter. Truffles have a fleshy interior and a round, warty exterior. They may be black, brown, or white.

Truffles grow mainly in temperate regions. The tastiest ones come from the Périgord region of southwestern France. White truffles found in Italy are also prized. Truffles have a strong odour, and trained dogs and pigs are often used to locate them. Wild truffles have declined in number, and most attempts to grow them commercially have failed. As a result, truffles are an extremely expensive delicacy.

Scientific classification. Truffles belong to the truffle family of ascomycete fungi, Tuberaceae. The Périgord variety, found in France, is *Tuber melanosporum.*

Truganini (1812-1876), was generally thought to have been the last tribal Tasmanian Aborigine. However, recent evidence indicates there may have been other tribal Tasmanian Aborigines who outlived Truganini. First, four Tasmanian women were taken by sealers to Kangaroo Island, off the South Australian coast. Each outlived Truganini. Second, a woman named Fanny Cochrane Smith, whose mother and probable father were tribal Aborigines, died near Cygnet, Tasmania, 29 years after Truganini's death.

Truganini was the daughter of Mangerner, chief of the Recherche Bay people. She grew up on Bruny Island. By the time she was 17 years old, she had seen her mother stabbed to death, her sisters captured by sealers, and her intended husband killed by woodcutters.

In 1829, Truganini met George Robinson, a white man who supported the rights of Tasmanian Aborigines. Robinson, Truganini, and other Aborigines travelled around Tasmania collecting the remaining Aboriginal people from their tribal lands. By 1834, the 135 remaining tribal Aborigines, including Truganini, were settled on Flinders Island, at the Wybalenna Settlement. There they were to be "civilized" and Christianized.

In 1839, Truganini left Wybalenna with Robinson, in theory to help him make peace with the Victorian Aborigines. But she escaped, and, with four other Tasmanians, attacked white settlers, killing two men. Two of her companions were hanged. Truganini was sent back to Wybalenna in 1842. By 1847, she was one of 47 survivors of the settlement. The government later decided to transfer the Aborigines to Oyster Cove, part of Truganini's tribal lands. It is said that she often swam across the D'Entrecasteaux Channel to visit Bruny Island and, together with William Lanney, would visit Fanny Cochrane Smith's family at Nicholls Rivulet, near Cygnet. Truganini was a close friend of Fanny's, and she took Fanny's children out on hunting trips, teaching them her skills.

Truganini died in Hobart, Tasmania, in 1876. Despite the fact that she was terrified of being mutilated and begged to be buried far away, her skeleton was on display for many years at the Tasmanian Museum and Art Gallery, in Hobart. Truganini's bones were returned to the contemporary Aboriginal people in

Truganini

1976, and her ashes were scattered over D'Entrecasteaux Channel.

See also **Robinson, George Augustus; Smith, Fanny Cochrane; Tasmanian Aborigines.**

Trujillo Molina, Rafael Leonidas (1891-1961), was the ruling force in the Dominican Republic for over 30 years. He was president from 1930 to 1938 and from 1942 to 1952. Even when he was not president, he controlled the country. Politically, his rule was severe. There were many plots against him, often spurred by exiles, chiefly after World War II. Trujillo was assassinated in 1961. He was born in San Cristóbal, Dominican Republic.

Truk Islands form a large island group in the western Pacific, about 2,900 kilometres southeast of Manila in the Philippines (see **Pacific Islands** [map]). They are part of the eastern Carolines. About 48 of them lie inside a barrier coral reef that forms a lagoon 64 kilometres wide. About 50 small islets lie along the reef. About 38,000 people live on the islands.

The French navigator Louis Duperrey first explored the islands in 1825. Germany bought them from Spain in 1899 but lost them to Japan in World War I. The United States took control in 1947 as part of a United Nations trusteeship. In 1980, Truk and other Carolines formed the Federated States of Micronesia. In 1986, these islands became a self-governing political unit in free association with the United States.

Truman, Harry S. (1884-1972), was president of the United States from 1945 to 1953. He became president at one of the most crucial moments of American history. Elected vice president in 1944, he had been in office for only 83 days when President Franklin D. Roosevelt died on April 12, 1945. At that time, World War II was still being fought. During the first few weeks of Truman's administration, the Allies won victory in Europe. Truman then made the awesome decision to use atomic bombs against Japan to end World War II.

Early life. Truman was born in Lamar, Missouri, U.S.A., on May 8, 1884. His parents chose the middle initial "S" without designating a middle name. Truman briefly attended business school in Kansas City, Missouri, and held a number of clerical jobs there. In 1906, he moved to Grandview, Missouri. Until 1916, he worked there with his father on the family farm.

In 1918, Truman served as a captain in the U.S. artillery in France, during World War I. In 1919, after the war, Truman invested his savings in a men's clothing store in Kansas City. The business failed during a severe recession that began in 1921.

Early political career. Discouraged by the failure of the store, Truman decided to seek a career in politics. He won several elections for county judge in the 1920's and early 1930's and earned a reputation for personal honesty and efficiency.

In 1934, Truman was elected to the U.S. Senate. In 1941, he was named chairman of a Senate committee to investigate defence spending. The Truman Committee, as the group became known, uncovered waste and inefficiency. It saved the government about 15 billion U.S. dollars and speeded war production.

Truman gained a national reputation as a result of his committee investigations. In 1944, the Democrats nominated him to be vice-presidential candidate in President Franklin D. Roosevelt's bid for reelection. Roosevelt and Truman easily defeated their Republican opponents, Governor Thomas E. Dewey of New York and Governor John W. Bricker of Ohio.

First administration (1945-1949). On April 12, 1945, Roosevelt died and Truman succeeded him as president. At that time, Allied armies were winning the war in Germany and were preparing to invade Japan. On April 25, the first United Nations conference met in San Francisco, California, U.S.A. Then, on May 7, Germany surrendered.

In July, Truman travelled to Potsdam, Germany, to confer with Prime Minister Winston Churchill of the United Kingdom and Premier Joseph Stalin of the Soviet Union (see **Potsdam Conference**). While in Potsdam, the president received word that American scientists had successfully tested an atomic bomb for the first time. On his way home, Truman ordered American pilots to drop an atomic bomb on Japan. The first bomb fell on the city of Hiroshima on August 6. Three days later, a second bomb was dropped on Nagasaki. Japan formally surrendered on September 2. See **World War II.**

The Truman Doctrine. Soon after World War II, Communists, aided by the Soviet Union, gained control over one nation after another in Eastern Europe. In 1947, Truman announced a doctrine of resistance to Communist aggression. The Truman Doctrine guaranteed American aid to all free nations resisting Communism. See **Cold War.**

The Marshall Plan, outlined by Secretary of State George C. Marshall in 1947, extended the Truman Doctrine. It proposed that the war-damaged nations of Europe join in a programme of mutual aid for economic recovery, assisted by grants from the United States. Communist nations rejected the plan, but 18 other countries eventually accepted it. See **Marshall Plan.**

Election of 1948. In 1948, the Democratic Party renominated Truman and picked Senator Alben W. Barkley of Kentucky as vice-presidential candidate. The Republicans again nominated Dewey for president, and chose Governor Earl Warren of California as his running mate. Every public opinion poll predicted that Dewey would win a landslide victory, partly due to Democratic disunity. With an extraordinary show of spirit, Truman conducted a vigorous campaign. He travelled thousands of kilometres by rail in a "whistle-stop" campaign and made more than 350 speeches. In one of the biggest upsets in U.S. political history, Truman defeated Dewey.

Second administration (1949-1953). Truman proposed an extensive programme of domestic reforms, which he called the "Fair Deal." It included (1) civil rights legislation, (2) removing restrictions on trade unions, (3) a new farm programme stressing high farm income and low consumer prices, (4) federal aid to education, (5) a federal housing programme, and (6) increases in the social security programme. Southern Democrats joined conservative Republicans to defeat most of the president's domestic proposals.

North Atlantic Treaty Organization (NATO). In 1949, Canada, France, the UK, the U.S.A., and eight other nations signed the North Atlantic Treaty, forming the North Atlantic Treaty Organization. They agreed that an attack on one member would be considered an attack on all. Other countries later joined NATO (see **North Atlantic Treaty Organization**).

Foreign Aid Programme. In 1950, Congress approved 35 million U.S. dollars for Truman's "Point Four Program." This programme of foreign aid was designed to make, in Truman's words, "the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas."

The Korean War began on June 25, 1950, when Communist forces from North Korea invaded South Korea. The UN demanded that North Korea withdraw. On June 27, Truman announced that he had sent U.S. planes and ships to help South Korea. That same day, the UN approved sending troops of other nations to South Korea. Truman ordered ground forces to South Korea on June 30.

General Douglas MacArthur commanded all UN forces in Korea. His troops brought most of Korea under UN control by October 1950. But later that month, Chinese Communist troops joined the North Koreans. MacArthur wanted to attack Chinese bases in Manchuria. But Truman believed that the fighting must be confined to Korea and not be allowed to spread into a possible global war. MacArthur made several public statements criticizing that policy. In April 1951, Truman dismissed MacArthur, creating a nationwide furore. See **Korean War.**

Elder statesman. Truman left office on Jan. 20, 1953, and retired to his home in Independence, Missouri, U.S.A. He published two volumes of his memoirs in 1955 and 1956. He also continued his active interest in politics and the Democratic Party.

Truman became ill in late 1972. He died in Kansas City, Missouri, on December 26.

Trumper, Victor (1877-1915), was an outstanding Australian batsman. He played in 48 test matches, scoring 3,163 runs at an average of 39.05 runs per innings. His highest test score was 214 runs, against South Africa, at Adelaide, South Australia, in 1911. In first-class matches, he scored 17,150 runs, at an average of 45.0 runs per innings. In one match, he scored 50 runs off 10 consecutive balls. Trumper did much to encourage schoolboys to play cricket. When he owned a sports shop in Sydney, he gave equipment to poor children. He was also one of the founders of Rugby League in Australia. Victor Thomas Trumper was born in Sydney.

Trumpet is a popular brass instrument in bands and orchestras. A player produces tones by blowing into a cup-shaped mouthpiece and vibrating the lips. The player changes notes by fingering the instrument's three valves and changing lip tension. The largest part of the trumpet consists of a curved tube. Most trumpets used in bands are pitched in the key of B flat and have a tube about 1.4 metres long. Orchestras use those kinds and ones with shorter tubes and pitched in other keys. The small diameter and cylindrical shape of its tube give the trumpet its brilliant, powerful sound.

Trumpets date back to about 1200 B.C. The valve trumpet was developed in 1813.

Trumpet creeper. See **Bignonia.**

Trundle bed. See **Bed** (picture).

Trunk. See **Tree** (The parts of a tree).

Truro is a city in Cornwall, England, known as a tourist centre. It is the county's administrative centre, and is in Carrick district. Truro, 13 kilometres north of Falmouth, stands where the Kenwyn and Allen rivers merge to form the River Truro. The city has a fine cathedral, built in the 1880's in the Gothic Revival style.

Trust. See **Antitrust laws.**

Trust estate. See **Trust fund.**

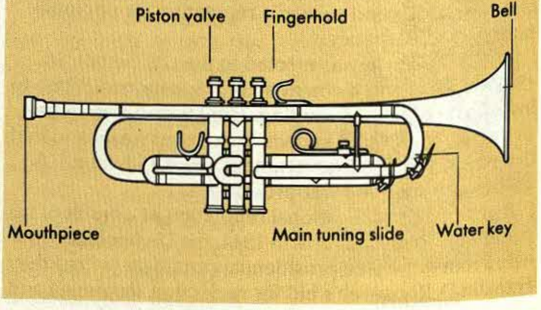
Trust fund is money or other property managed by one person or group for the benefit of another person or group. Other terms for a trust fund include *corpus, principal,* and *trust estate.* The arrangement under which a trust fund is managed is called a *trust.*

In some cases, the property in a trust fund is taxed less heavily than property owned without such an arrangement. As a result, many people establish trust funds to reduce their taxes. Others create trust funds for the benefit of children or other people who cannot manage property themselves. Some people use trust funds to take advantage of an individual's or institution's special skill in managing property.

How a trust fund works. Most trust funds involve three parties: a *trustor,* a *trustee,* and a *beneficiary.* In some cases, the trustor is also the trustee or the beneficiary. The trustor, also called the *settlor* or *donor,* creates a trust fund by giving property to a trustee. The trustee holds or invests the fund for the good of the beneficiary. The trustee may have charge of the fund for a few years or for more than a lifetime, depending on the terms of the trust. After the trust has *terminated* (ended), the trustee distributes the property as directed under the terms of the trust.

Any sane adult may serve as a trustee. However, most trust funds are handled by *trust departments* of banks or by businesses called *trust companies.* In most cases, the fee for the trustee's services is set by an agreement between the trustor and trustee. Trustees must keep accounts of all trust funds they hold, invest, or distribute. In addition, they must follow the trustor's wishes concerning investment of the fund. If the trust does not indicate the trustor's wishes for investment, the trustee must follow guidelines set by law. A trustee must make good any losses that result from wrongful use of a trust fund.

The trumpet is a popular brass instrument with a brilliant tone. A trumpet player can produce all notes of the scale by pressing the instrument's three piston valves in various combinations.



Beneficiaries receive income from trust funds according to a variety of arrangements. For example, some beneficiaries periodically receive income earned by the trust fund. Other beneficiaries must wait and receive the accumulated income from the fund when they reach a certain age. Some beneficiaries receive payments from the trust fund until they reach a certain age, when they take possession of the fund themselves.

Kinds of trusts. There are several kinds of trusts. A trust that operates during the trustor's life is called a *living* or *inter vivos trust.* A trust established by a will is called a *testamentary trust.* A *revocable trust* can be changed or abolished by the trustor. A trustor who gives up all rights to the trust fund creates an *irrevocable trust.* Trusts established for the benefit of churches, colleges, or other nonprofit organizations are *charitable trusts. Life insurance trusts* receive the proceeds of insurance policies on the life of the trustor.

Courts occasionally create *constructive trusts* to protect property. For example, a person who has property that belongs to another may be named *constructive trustee* of that property. Such an arrangement protects the property and ensures that it will be returned to the rightful owner.

Trust territory refers to an area administered by a country under the supervision of the United Nations (UN) Trusteeship Council. The administering country has complete authority over the government of a trust territory. It administers the territory under an agreement with the UN according to principles set down in the UN Charter.

A total of 11 trust territories were established after World War II ended in 1945. They included the former Italian colony of Somaliland and 10 of the 11 former mandates of the League of Nations (see **Mandated territory**). The 11th mandate, Namibia (South West Africa), remained under South Africa's control. Of the 11 trust territories, all but the U.S.-administered Trust Territory of the Pacific Islands became independent or voted to become a part of an independent nation between the mid-1950's and the mid-1970's. In 1986, all of the units of the Trust Territory of the Pacific Islands except the Palau Islands gained self-government.

See also **United Nations** (The Trusteeship Council).

Trustee. See **Trust fund.**

Trusteeship Council. See **United Nations** (The Trusteeship Council).

Trusthouse Forte, formed in 1970, is one of the world's largest hotel and catering groups. It operates more than 800 hotels and holiday villages throughout the world, 230 of them in Britain and Ireland. It operates over 3,000 restaurants and other catering centres. In the British Isles, these centres include quality restaurants, motorway service stations, and cafés. The group also organizes airport shops and restaurants and catering facilities on trains and aircraft. Retail interests include the sports store, Lilleywhites, in London.

Truth, Sojourner (1797?-1883), was the name used by Isabella Baumfree, one of the best-known American abolitionists of her day. She was the first black woman orator to speak out against slavery. She travelled widely through the New England states of the United States and the U.S. Midwest on speaking tours. Her deep voice, quick wit, and inspiring faith helped spread her fame.

Sojourner Truth

Baumfree was born a slave in Ulster County, New York. She became free in 1828 under a New York law that banned slavery. In 1843, she experienced what she regarded as a command from God to preach. She took the name Sojourner Truth and began lecturing in New York. Her early speeches were based on the belief that people best show love for God by love and concern for others. She soon began directing her speeches toward the abolition of slavery.

In 1864, she visited President Abraham Lincoln in the White House. She stayed in Washington, D.C., and worked to improve living conditions for blacks there. She also helped find jobs and homes for slaves who had escaped from the South to Washington. In the 1870's, she tried to persuade the U.S. federal government to set aside undeveloped lands in the West as farms for blacks. But her plan won no government support.

Truth serum. See **Thiopentone sodium.**

Truth table is a method of showing logical relationships. Truth tables are used by computer engineers, logicians, and others who reason by means of symbolic logic.

To understand truth tables, we must first understand some ideas of logic. A basic declarative sentence is a *proposition* if its meaning can be classified as true or false. For example, the sentences *"The door is open."* and *"The light bulb is not burned out."* are both propositions.

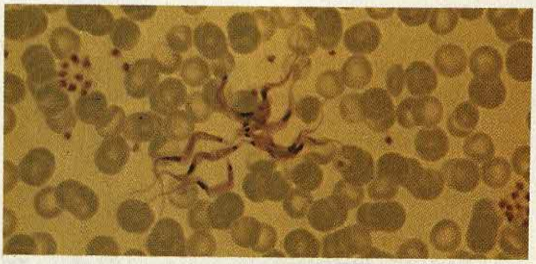
A limited number of propositions when combined may form a *propositional function.* For example, the two propositions above may be combined into the propositional function *"The light in the refrigerator will be on if the door is open and the light bulb is not burned out."* The truth or falsity of a propositional function depends on the truth or falsity of each of the basic propositions and the way the function relates them.

The truth table corresponding to the above propositional function would look like this:

Basic propositions		**Propositional function**
Door open	**Bulb not burned out**	**Light on**
false	false	false
false	true	false
true	false	false
true	true	true

The table lists all combinations of true and false values that can be assigned to the basic propositions. The table is completed by indicating the truth or falsity of the propositional function for each entry.

Trypanosome is a microscopic one-celled organism. It is a parasite in the blood and spinal fluid of human beings and other vertebrates. Some trypanosomes are parasites in plants. One kind causes African sleeping sickness. Others cause Chagas' disease and nagana, an Af-



Trypanosomes, *centre,* are shown among blood cells.

rican disease of animals. A trypanosome is long and thin, with a whiplike extension at one end called a *flagellum.* It also has a thin waving membrane down the length of its body. Many trypanosomes spend part of their lives inside certain insects.

Scientific classification. Trypanosomes belong to the kingdom Protista, family Trypanosomidae. One trypanosome that causes sleeping sickness is *Trypanosoma gambiense.*

See also **Tsetse fly; Sleeping sickness.**

Tsar. See **Czar.**

Tschaikowsky, Peter Ilich. See **Tchaikovsky, Peter Ilich.**

Tserclaes, Johan. See **Tilly, Count of.**

Tsetse fly is a two-winged fly of Africa. It carries the animal parasites that cause African sleeping sickness. These parasites are called *trypanosomes.*

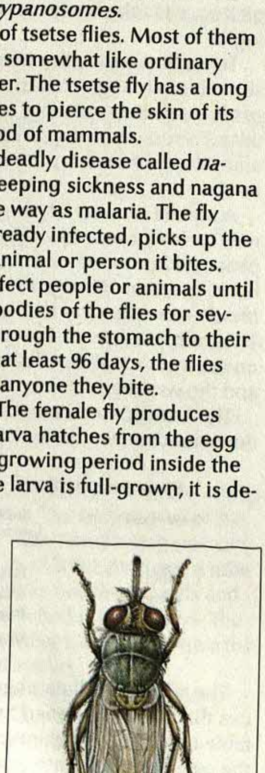
There are about 20 kinds of tsetse flies. Most of them attack people. The flies look somewhat like ordinary houseflies, but they are larger. The tsetse fly has a long *proboscis* (beak) which it uses to pierce the skin of its victim. The fly sucks the blood of mammals.

The tsetse fly transmits a deadly disease called *nagana* to cattle and horses. Sleeping sickness and nagana are spread in much the same way as malaria. The fly bites an animal or person already infected, picks up the germs, and infects the next animal or person it bites.

The flies usually cannot infect people or animals until the germs have lived in the bodies of the flies for several days and have passed through the stomach to their salivary glands. But then, for at least 96 days, the flies can transmit the parasites to anyone they bite.

Tsetse flies breed slowly. The female fly produces only one egg at a time. The larva hatches from the egg and is nourished during the growing period inside the body of the parent. When the larva is full-grown, it is deposited on the ground, and it becomes a pupa.

Both male and female flies are active bloodsuckers. They are found chiefly along lake shores or river banks, making parts of Africa uninhabitable. In some regions, insecticide sprays control tsetse fly populations. Other successful control programmes use radiation to sterilize male flies, making them unable to reproduce. Drugs that protect cattle from nagana are also used. However, political unrest has hampered control efforts in many parts of Africa.



Tsetse fly

Scientific classification. The tsetse fly belongs to the house fly and blow fly family, Muscidae. The most dangerous tsetse flies are *Glossina palpalis* and *G. morsitans.*

See also **Sleeping sickness; Trypanosome.**

Tsonga is a South African tribe. Most Tsonga people live in the northeast of the country, between the St. Lucia estuary and the Mozambique border. They speak many dialects, and have been known by many different names, including Tonga, Thonga, and Shangaan. When the Portuguese explorer, Vasco da Gama, encountered the Tsonga in 1498, they were traders in metal and ivory.

Fishing was the main source of food. But the Tsonga also grew crops such as sorghum, and raised goats and poultry. Shoshangane, leader of one of the Nguni-speaking tribes, conquered them in the early 1820's and influenced their customs and language. Some fled to the Transvaal. Tsonga men were among the first of South Africa's migrant workers, especially in the diamond fields. In 1895, the United Kingdom annexed their territory to prevent the Transvaal Boers from gaining access to a port.

TSS. See **Toxic shock syndrome.**

Tsunami. See **Tidal wave.**

Tsushima, Battle of. See **Navy** (Famous sea battles).

Tswana is the Bantu language spoken by people living in western parts of South Africa, including Botswana and Bophutswana (see **Bantu**). The main Tswana-speaking groups include the Kgatla, Rolong, Hurutshe, and Kwena. Farmers with a culture like that of the Tswana people have lived in the area since the A.D. 400's. Tswana chiefdoms in the Witwatersrand area date from as long ago as the 1200's. A related group, the Khalagari or Kgalagadi, have a long history of settlement in present-day Botswana.

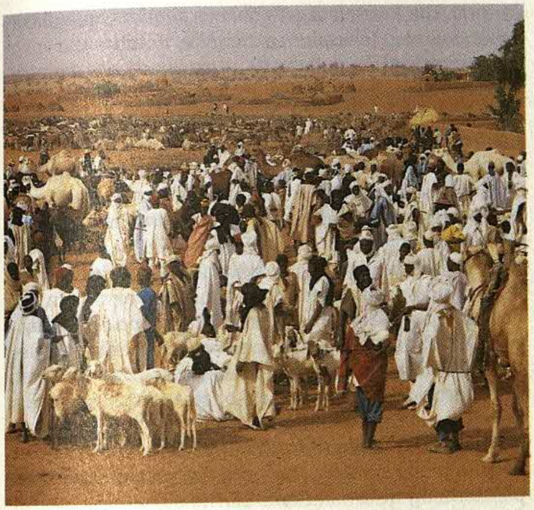
Traditional Tswana societies were characterized by the size of their towns and cattle herds. Their stone-walled towns had populations of up to 10,000 people. During the early 1800's, the Tswana were devastated by raids of the Ndebele under their ruler Mzilikazi and then were brought under Boer rule (see **Boers**).

Tuamotu Islands are an island group in the South Pacific (see **Pacific Islands** [map]). The Tuamotu group is made up of 75 reef islands and *atolls* (rings of coral islands). The islands stretch across almost 1,600 kilometres of water, and have dangerous sunken reefs. They cover about 775 square kilometres, and have a population of about 11,000. Polynesians live on the islands. Pearls and copra are the chief sources of income.

In 1606, Pedro Fernandez de Quiros, a Portuguese explorer in the service of Spain, became the first European to see the islands. A native king ruled the islands until 1881, when France annexed them. The islands are now part of French Polynesia, an overseas territory of France. France began using Mururoa atoll, in the Tuamotu group, as a nuclear bomb test area in 1965.

Tuareg are the largest group of nomads living in the Sahara. More than 300,000 Tuareg live in the desert, chiefly in Algeria, Mali, and Niger. The Tuareg are Muslims. They are related to the Berbers of northern Africa and speak a Berber language (see **Berbers**).

Most Tuareg herd camels, goats, sheep, and cattle and move about in areas of the Sahara where seasonal



Tuareg shepherds gather in a marketplace in Niger, *above.* The Tuareg are the largest group of nomads in the Sahara.

rainfall provides pasture for their livestock. Tuareg families live in tents made of either goatskins or mats woven from palm leaves. Men tend the herds, and women milk the livestock and grind grain to prepare meals. Milk is the most important food in the Tuareg diet.

The Tuareg are sometimes called the *Blue Men of the Desert.* They often wear indigo-dyed robes, which leave a blue colour on their skin. The men wear turbans for protection against sandstorms and the sun. They wrap the turbans around their heads and across their faces to form a veil so that only their eyes can be seen.

Tuareg society has three main social classes—nobles, vassals, and slaves. The Tuareg are organized into confederations that consist of several noble and vassal tribes. A chief heads each confederation. The vassals in each confederation choose a noble as chief. Women and men are considered social equals. Husbands and wives separately own property, including livestock.

The Tuareg are believed to be descendants of people who originally lived in Libya over 2,000 years ago. The Tuareg fought against Turkish, Arab, and European rulers of North Africa over the years. They were fiercely independent until the French defeated them during the late 1800's and early 1900's. Droughts have always threatened their nomadic life. During a drought that lasted from 1968 to 1974, thousands of Tuareg and entire herds of their cattle died.

Tuart is the Aboriginal name for a Western Australian eucalyptus. It grows to about 40 metres tall. It has a rough bark; narrow, lance-shaped, grey-green leaves; and stalkless, bell-shaped fruit. It grows in a belt about 2 kilometres wide, from just north of Perth to Busselton in the south, behind the coastal sand dunes on limestone country. This area is frost-free, and has 75 to 100 millimetres of rainfall each year. This is the only stand of tuart in the world. The timber is one of the heaviest and strongest in Australia but is not resistant to *termites* (white ants). It is used in constructing railway carriages.

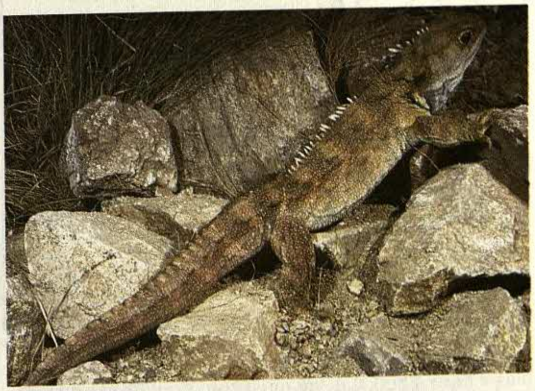
Scientific classification. Tuart belongs to the family Myrtaceae. It is *Eucalyptus gomphocephala.*

Tuatara is a lizardlike reptile that lives only on a few small islands off the coast of New Zealand. Tuataras are the only living members of an ancient group of reptiles that appeared on the earth more than 200 million years ago.

Tuataras have scaly, grey or greenish skin. They have a crest of enlarged scales down the back and tail. Male tuataras can grow more than 60 centimetres long. Females are shorter.

Tuataras sleep during the day, often in burrows dug by sea birds. They emerge from the burrows at night to hunt insects, amphibians, snails, birds, and small lizards. Tuataras have sharp teeth with which they easily tear up prey. A tuatara's tail breaks off easily. If an enemy seizes the tail, the tuatara sheds the tail and escapes. It then grows a new tail.

After mating with a male, the female tuatara carries from 8 to 15 eggs inside her body for nearly a year. She then deposits the eggs in a burrow, where they develop for more than a year before hatching. The eggs of no other reptile take as long to develop.



The tuatara is a reptile found only on a few small islands off the New Zealand coast. Tuataras grow to about 60 centimetres in length.

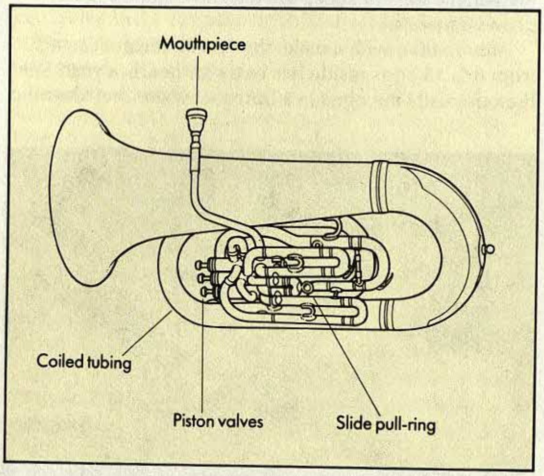
Tuataras grow slowly and do not mate until about 20 years of age. These animals live a long time. The longest a tuatara is known to have lived is 77 years.

Scientific classification. The tuatara belongs to the class Reptilia, order Rhynchocephalia. It is *Sphenodon punctatus.*

Tuba is the general name for a number of musical instruments in the brass family. Tubas are the largest of the brass instruments and have the lowest pitch, serving as the bass voice in a brass section. A musician plays the tuba by vibrating the lips in a cup-shaped or funnel-shaped mouthpiece. The musician changes notes by changing lip tension and fingering the instrument's valves to change the length of the vibrating column of air. Other brass instruments are held in a horizontal position, but the tuba is held vertically.

One popular type of tuba is the *baritone.* It is also called the *euphonium* or the *tenor tuba,* depending on the manufacturer and the diameter of the instrument's tubing. The baritone has three or four valves and is widely used in concert bands and marching bands. The large *upright tuba* appears in symphony orchestras. It has from three to five valves. The three-valve *sousa-*

The upright tuba is used in the brass section of symphony orchestras. The instrument is played in a seated position with the bell pointed upward.



phone wraps around the musician's body and has a large flaring bell. It is the most common tuba in marching bands. The three-valve *marching bugle tuba* is a popular instrument in drum and bugle corps. The tuba is the newest member of the brass family.

Tube. See **Electronics** (Electron tubes); **Television** (Amplifiers and separators; The picture tube); **Vacuum tube.**

Tube. See **London** (Transportation).

Tube worm is the name for marine worms that live in tubes. The tubes are made of mucus and are strengthened with mud, sand particles, and shell fragments.

Sabellid tube worms have tubes made of sand particles. The tubes stick upright from the sea bed. These worms have two whorls of feathery tentacles that stick out from the end of the tube. These tentacles pick up and trap small food particles from sea water. The tentacles also act as organs of respiration. These worms are also called fan worms or feather duster worms.

Serpulid tube worms construct hard tubes of calcium carbonate. Some types look like squeezed out tubes of toothpaste. Others have coiled tubes like snail shells.

Scientific classification. Tube worms belong to the phylum Annelida, class Polychaeta.

Tuber is the thick, enlarged part of a stem that grows underground. The potato is the best example of a tuber. The tuber stores the food, usually starch, for the plant. It has small scalelike leaves and tiny buds known as *eyes.* These eyes sprout new plants, which obtain their food from the tuber until their own roots and leaves are formed. The Jerusalem artichoke is another example of a tuber. See also **Jerusalem artichoke; Potato.**

Tuberculosis is an infectious disease that mainly affects the lungs but can also involve other organs. Tuberculosis is often called *TB* and was called *consumption* in the past. This disease once ranked among the most common causes of death in the world. Today, improved methods of prevention, detection, diagnosis, and treatment have greatly reduced both the number of people who get the disease and the number of people who die from it. However, tuberculosis remains a major concern in developing countries where these improvements are not widely available, and where living conditions may be poor. Tuberculosis has become a concern in industrial countries, among homeless people.

Tuberculosis strikes people of all ages but is more common among the elderly. Other people at greater risk of getting tuberculosis include those with weakened immune systems, such as AIDS patients, and people suffering from malnutrition. The disease can also afflict animals, especially such livestock as cattle, pigs, and poultry. The disease is caused by rod-shaped bacteria called *tubercle bacilli.* The German doctor Robert Koch discovered tubercle bacilli in 1882. They are sometimes called *Koch's bacilli* (see **Koch, Robert**). Tubercle bacilli belong to a *genus* (group) of bacteria called *Mycobacterium.* They are *aerobes*—that is, they must have oxygen to live.

How tuberculosis affects the body

In most cases, a person becomes infected with tubercle bacilli by inhaling tiny droplets of moisture that contain *Mycobacterium tuberculosis* bacteria. These droplets form when a person with tuberculosis coughs or sneezes. Infection can also result from eating contaminated food or from drinking milk from cattle infected with *Mycobacterium bovis* bacteria. Such infection rarely occurs in industrial countries, where milk is pasteurized and animals are routinely tested for diseases.

The body expels many inhaled tubercle bacilli before they can do harm. Some bacilli settle into the layer of mucus that lines most of the respiratory system, including the nasal passages and the *tracheobronchial tree.* The tracheobronchial tree is the branching system of tubes that brings air to and from tiny air sacs called *alveoli* in the lungs. It consists of the *trachea* (windpipe), two *bronchi,* and hundreds of thousands of smaller airways called *bronchioles.* It is lined with cells that can move the layer of mucus covering them upward. Bacilli trapped in the mucus layer are moved up the airways toward the throat, mouth, and nose. The bacilli may then be sneezed, spat, coughed, or blown out. They may also be swallowed and pass harmlessly through the digestive tract.

Primary infection is likely to result from tubercle bacilli that penetrate beyond airways lined with mucus into the alveolar sacs deep in the lungs. Primary infection is a stage in the development of tuberculosis, but it does not always lead to the disease. Tubercle bacilli that enter an alveolar sac are usually engulfed by large, amoebalike cells called *alveolar macrophages.* Normally, these cells are able to digest bacteria. However, tubercle bacilli resist digestion and most of them actually thrive and multiply inside the macrophages. Some of the macrophages carrying these bacteria may migrate to the mucus layer and be carried out of the body. Others may carry the bacteria to another part of the lungs, or into the lymph to a nearby lymph node, or even into the blood.

Within several weeks of the initial infection, a small, hard swelling called a *tubercle* forms in the alveolar sac. The tubercle begins to form as macrophages containing tubercle bacilli clump together. These macrophages are joined by *T cells* and possibly other white blood cells. In time, these clumps of cells grow larger and destroy surrounding lung tissue.

As cells inside the tubercle die, they form *caseous* (soft, cheeselike) areas that support the growth of tubercle bacilli. At the same time, tough scar tissue begins to surround the tubercles. This scar tissue prevents further spreading of the bacilli, and it may decrease the amount of oxygen they receive. The bacilli walled off by the scar tissue remain alive but inactive.

In an otherwise normal, healthy adult, primary infection by tubercle bacilli may produce no symptoms and may thus go undetected. In some cases, however, primary infection causes such symptoms as fever, rash, or nausea.

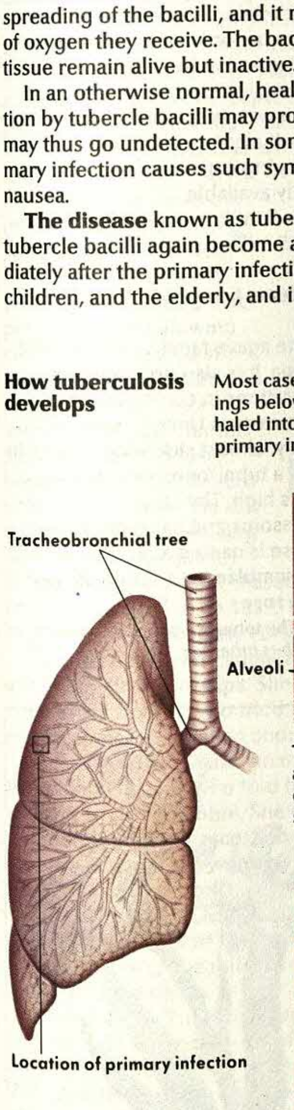
The disease known as tuberculosis develops if the tubercle bacilli again become active. It may occur immediately after the primary infection, especially in infants, children, and the elderly, and in people who have other illnesses. In most cases, however, tuberculosis develops long after the primary infection has occurred. What causes this reactivation of the bacilli is not entirely clear. It may occur when the body's defence mechanisms are impaired by another illness or by old age, or it may result from a second infection by tubercle bacilli. Reactivation of the bacteria causes the tubercles to rupture and the bacilli to reproduce rapidly. Cells may carry the bacteria to other parts of the lung or into the lymph vessels. The bacteria also may enter blood vessels and be transported to other organs, including the bones, brain, joints, kidneys, and skin.

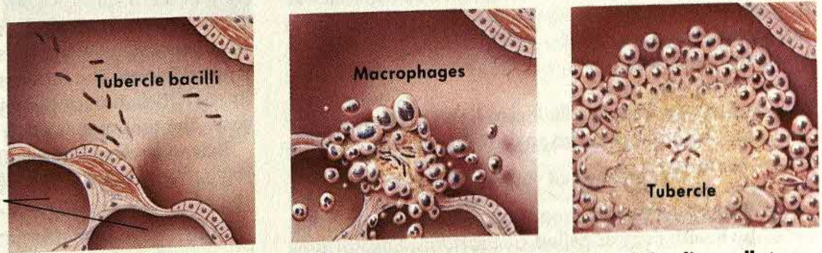
In tuberculosis of the lungs, called *pulmonary tuberculosis,* alveolar macrophages and white blood cells accumulate at the sites of the reactivated bacteria and form caseous material. The caseous material eventually liquefies and moves up the respiratory tract with the mucus layer. The patient coughs this mucus and caseous material up as *sputum.*

Coughing and sputum production are the most common early symptoms of pulmonary tuberculosis. The cough is not usually severe and the symptoms are often mistaken for a lingering cold. If blood vessels in the lungs are damaged, there may be blood in the sputum. In advanced stages of the disease, the patient may cough up large quantities of blood. Other symptoms of advanced tuberculosis include chest pain, fever, sweating at night, fatigue, weight loss, and loss of appetite. Al-

How tuberculosis develops

Most cases of tuberculosis begin with an infection deep in the lung, *left.* The top series of drawings below shows how invading bacteria called *tubercle bacilli* cause a primary infection when inhaled into the lung. The bottom drawings illustrate how tuberculosis can later develop from the primary infection. This may occur when the body's defence mechanisms are impaired.

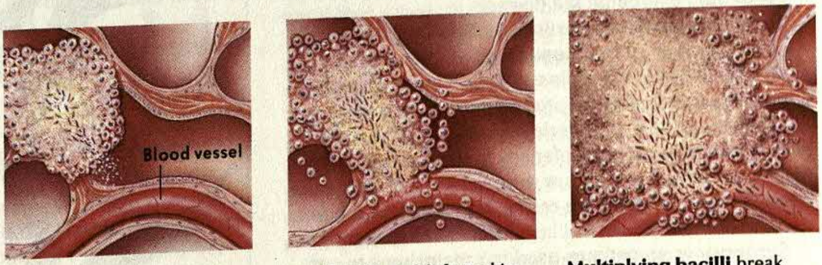




Tubercle bacilli in the air are inhaled deep into the tiniest tubes of the lung at the start of a primary infection.

Macrophages attack the invading bacilli. These cells may kill the bacteria or engulf them without killing them.

Other defending cells trap the remaining bacilli in hard lumps called *tubercles.* The trapped bacilli are harmless.



The bacilli break out of the tubercles if the body's defences weaken. This marks the start of tuberculosis.

The bacilli multiply and invade surrounding tissue. Macrophages unsuccessfully attack the bacilli.

Multiplying bacilli break through the lung tube wall and invade a blood vessel. They may then spread.

though tuberculosis may lead to a rapid death, it occurs more commonly as a long-term, progressively worsening disease.

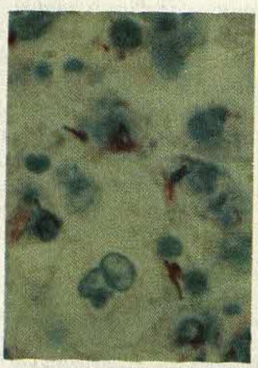
Diagnosis of tuberculosis

Doctors use several methods to detect tuberculosis. The chief methods are skin tests, chest X rays, and laboratory tests.

Skin tests can determine if a person has been infected with tubercle bacilli in the past. However, such tests do not tell the doctor whether the active disease is present. All types of skin tests are based on specific allergic reactions to the tubercle bacilli. The body develops the allergy to the bacilli within a few weeks after the primary infection.

Chest X rays may reveal tubercles or other signs of tuberculosis in the lungs. Chest X rays are usually done after a skin test has indicated a previous infection. However, chest X rays done for other reasons sometimes reveal the presence of tubercles.

Laboratory tests are normally the final step in the diagnosis of tuberculosis. A technician examines the patient's sputum to determine if bacilli are present. Sputum samples are treated with chemicals and stains to make the bacilli visible under the microscope. If bacilli are present, they are *cultured*—that is, grown in laboratory dishes or test tubes. Culturing determines whether they are *Mycobacterium tuberculosis* or other bacilli. It also helps find out which drugs will be most effective against the bacteria.



In diseased lung tissue, *above,* tubercle bacilli appear as short, red rods. This photograph magnifies the tissue 200 times.

Treatment of tuberculosis

The first effective treatment for tuberculosis was provided by health centres called *sanatoriums.* Sanatoriums were developed during the late 1800's by doctors in Europe and the United States. At a sanatorium, tuberculosis patients received bed rest, fresh air, and mild exercise. They were also isolated and thus kept from infecting other people. Sanatorium treatment helped many people overcome the disease.

Today, almost all tuberculosis patients can be treated successfully with drugs. Isoniazid (INH) is one of the most effective antituberculosis drugs. Others include rifampicin, ethambutol, streptomycin, and pyrazinamide. These drugs stop the bacteria from multiplying and allow the body's natural defences to work. Doctors normally prescribe two or more drugs at a time because tubercle bacilli may become resistant to only one medication. A course of treatment lasts from six to nine months.

Surgery was sometimes used in sanatoriums to collapse a diseased lung, both to rest the lung and to decrease its oxygen level to discourage the growth of the tubercle bacilli. Doctors still perform surgery in some rare cases, but they remove the afflicted part of a tubercular lung rather than collapse the lung. The remaining part continues to function normally.

Prevention of tuberculosis

The drug isoniazid prevents most detected tuberculosis infections from developing into the disease. Doctors often prescribe isoniazid for people who have a positive skin test. They may also give the drug to people at special risk who live with an infected person. In hospitals and other places where patients come into contact with non-infected people, the use of ultraviolet overhead light helps prevent the disease from spreading.

A vaccine called BCG *(Bacillus Calmette-Guérin)* has been used in many parts of the world in an effort to prevent tuberculosis. However, the vaccine is not always effective, especially among certain populations, and some strains of tuberculosis have become resistant to drugs.

Treatment and preventive action have greatly reduced the number of tuberculosis cases in industrial countries. However, the disease is spreading among the homeless in these nations. It also remains a major problem in a number of developing nations, where drugs for tuberculosis are not readily available.

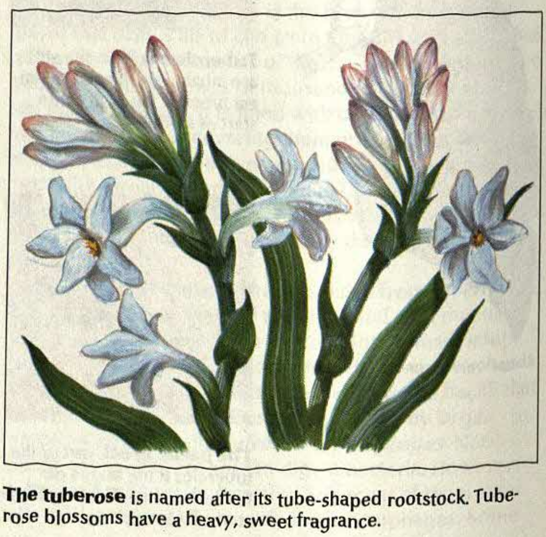
In 1990, there were over 7 million cases of tuberculosis worldwide, and over 2.5 million people died from the disease.

See also **Scrofula; Trudeau, Edward L.; Veterinary medicine.**

Tuberose is a plant of the agave family. It grows wild in tropical America and Asia. It is also grown for use in perfumes and toilet preparations in central Europe, southern Africa, and in the eastern United States.

The tuberose has a heavy, almost sickening, odour. Its slender stem springs from a tubelike rootstock, and often grows 90 centimetres high. The stem of the tuberose bears waxy-white blossoms and has eight sword-shaped leaves. The tuberose is named after the shape of its rootstock, not for its resemblance to a tube-shaped rose. The tuberose is not a rose.

Scientific classification: The tuberose belongs to the agave family, Agavaceae. It is *Polianthes tuberosa.*



The tuberose is named after its tube-shaped rootstock. Tuberose blossoms have a heavy, sweet fragrance.

Tubman, Harriet (1820?-1913), was a black American whose daring rescues helped hundreds of slaves escape to freedom. She became the most famous leader of the *underground railroad,* which aided slaves fleeing to the free states or to Canada. Blacks called her Moses, after the Biblical figure who led the Jews from Egypt.

Tubman was born a slave in Bucktown, near Cambridge, Maryland, U.S.A. Her name was Araminta Ross, but as a child, she became known by her mother's name, Harriet. Her father taught her a knowledge of the woods that later helped her in her rescue missions. When Harriet was 13, she interfered with a supervisor to save another slave from punishment. The enraged supervisor fractured Harriet's skull with a weight. She recovered but suffered blackouts for the rest of her life. She married John Tubman, a freed slave, in 1844.

Harriet Tubman escaped from slavery in 1849 and went to Philadelphia via the underground railroad, without her husband. She then vowed to return to Maryland and help other slaves escape. Tubman made her first trip back shortly after the U.S. Congress passed the Fugitive Slave Act of 1850. This law made it a crime to help a runaway slave. Tubman returned 18 more times during the 1850's and helped about 300 slaves escape.

During one rescue mission, Tubman sensed that pursuers were following close behind, and so she and the fugitives boarded a southbound train to avoid suspicion. On another mission, Tubman had just bought some live chickens in Bucktown when she saw her former master walking towards her. She quickly let the chickens go and chased after them before he could recognize her. In 1857, Tubman led her parents to freedom in Auburn, New York, U.S.A.

Harriet Tubman

Tubman never was caught and never lost a slave on any of her 19 rescue trips. She carried a gun and threatened to kill anyone who tried to turn back. Rewards for her capture once totalled about 40,000 U.S. dollars.

In the late 1850's, Tubman met with the radical abolitionist John Brown, who told her of his plan to free the slaves (see **Brown, John**). She considered Brown the true liberator of her race. Soon afterward, Tubman also became active in the women's rights movement in New England and New York.

In the American Civil War (1861-1865), Tubman served as a nurse, scout, and spy for the Union Army in South Carolina. During one military campaign, she helped free more than 750 slaves.

After the war, Tubman returned to Auburn, where she helped raise money for black schools. The author Sarah H. Bradford wrote *Scenes in the Life of Harriet Tubman* (1869), which described Tubman's work against slavery. In 1908, Tubman established a home in Auburn for elderly and needy blacks. It became known as the Harriet Tubman Home. The people of Auburn erected a plaque in her honour. A U.S. postage stamp bearing her portrait was issued in 1978.

Tubman, William V. S. (1895-1971), was president of Liberia from 1944 until his death in 1971. Educated in Liberia, he became a lawyer, and later a senator and associate justice of the Liberian Supreme Court. As president, he worked for progress in health, agriculture, and education. Tubman was born in Harper, Liberia.

See also **Liberia** (History).

Tubular bells. See **Chimes.**

Tuchman, Barbara Wertheim (1912-1989), was an American historian who won two Pulitzer Prizes for general nonfiction. She received the first in 1963 for *The Guns of August* (1962), which deals with the early phase of World War I (1914-1918). She won the second in 1972 for *Stilwell and the American Experience in China, 1911-1945* (1971), which centres on the career of the U.S. general Joseph W. Stilwell.

Tuchman was born in New York City. During 1934 and 1935, she worked as a research assistant for the Institute of Pacific Relations. She then became a reporter for the *Nation* magazine and covered the Spanish Civil War (1936-1939). Her first book, *The Lost British Policy: Britain and Spain Since 1700,* was published in 1938. Her other historical works, many of them best sellers, include *Bible and Sword: England and Palestine from the Bronze Age to Balfour* (1956), *The Zimmermann Telegram* (1958), *The Proud Tower: A Portrait of the World Before the War, 1890-1914* (1966), *Notes from China* (1972), *A Distant Mirror: The Calamitous Fourteenth Century* (1978), *Practicing History: Selected Essays* (1981), and *The March of Folly: From Troy to Vietnam* (1984).

Barbara Tuchman

Tucker, Albert (1914-   ), an Australian painter, portrayed the devastating effects of World War II on Australian cities. His portraits of murderers and other criminals are comparable with those of the German expressionists. His series entitled *Images of Modern Evil* is a striking criticism of the period. In 1960, after 12 years in Europe, he returned to Australia and found his subject material in Australian history. Tucker's pioneers seem to be cut from wood rather than painted, and his colourful parrots hurtle through the air like solid objects. This sculptural quality has enabled some of his work to be translated successfully into bronze. A critic described Tucker's landscapes as being like the cratered landscapes one might expect to find on the moon. Tucker was born in Melbourne. He was a self-taught painter.

Tucson (pop. 405,390; met. area pop. 531,443) is the second largest city in Arizona, U.S.A. It is a commercial and research centre of the U.S. Southwest. Tucson's warm, dry, sunny climate makes it a popular health and winter resort area. Many retired men and women have settled there.

The University of Arizona and the federal, state, and local governments are the city's major employers. Tucson's industries include tourism, electronics manufacturing, and the production of copper.

Tucumán (pop. 473,271) is a city in northwestern Argentina. Its full name is San Miguel de Tucumán. Tucumán lies at the foot of the Andes Mountains. It is the capital of the province of Tucumán. For location, see **Argentina** (political map).

Tucumán serves as the chief commercial centre of northwestern Argentina. It is an important centre of sugar production. Irrigated sugar cane fields lie outside the city. Other important industries in Tucumán include meat, milk, and grain processing. The National University of Tucumán is in the city. Tucumán was founded by Spanish settlers in 1565. Parts of the city still have Spanish colonial architecture. Argentina's declaration of independence was signed in Tucumán in 1816.

Tudor, House of, was the family that ruled England from 1485 to 1603. The first Tudor ruler was Henry VII. He won his crown at the battle of Bosworth Field, defeating Richard III and ensuring a victory for his own side in the Wars of the Roses. Henry claimed the throne through his mother, Margaret Beaufort, a descendant of Edward III. He also claimed he had a *divine right* to rule—that is, that his right to govern came from God. Henry restored order to England after 30 years of repeated outbreaks of civil war.

His son, Henry VIII, continued Henry VII's work of unifying the country. Henry VIII broke all ties between England and the Roman Catholic Church and made the monarch head of the church in England. Henry VIII was succeeded first by his son, Edward VI, and then in turn by his daughters, Mary I and Elizabeth I. The reigns of Edward and Mary were short and unhappy owing to civil unrest, foreign wars, severe economic problems, and religious disturbances. But under Elizabeth, England became a major European power. After Elizabeth's death in 1603, the crown passed to King James VI of Scotland, the great-grandson of Henry VII's oldest daughter. He was England's first Stuart king.

See also **England** (History); **Henry VII; Henry VIII.**

Tuesday is the name of the third day of the week. Its name comes from *Tiu,* or *Tiw,* the old Anglo-Saxon form of *Tyr,* name of the Norse god of war. Tyr was the son of Odin, or Woden, after whom Wednesday was named. The French call Tuesday *Mardi,* after Mars, the Roman war god. *Shrove Tuesday,* the day before Lent, was so-called because it was customary to confess and be *shriven* or *shrove* (receive absolution) by a priest. See also **Shrove Tuesday; Week.**

Tugboat, also called *tug* or *towboat,* is a small, powerful boat that manoeuvres large vessels. Tugboats operate at sea, on rivers and canals, and in channels and harbours. They get their power from a steam, diesel, or diesel-electric engine. Tugs used in harbours can tow large ocean liners or freighters and aid all types of vessels in entering or leaving their anchoring places. They can tow from the front or side, or push from the back. Tugs measure from about 20 to 75 metres long. They are driven by engines 1,500 to 16,500 kilowatts power. The largest tugboats are the oceangoing tugs, which rescue or assist ships at sea. Tugboats used on inland lakes and rivers tow or push long lines of barges loaded with heavy cargoes. Modern tugboats can push 40 or more barges at once. See also **Barge** (picture).

Tugendhat, Sir Christopher (1937-), was a Common Market commissioner for the United Kingdom from 1977 until 1985. Tugendhat was born in London and educated at Ampleforth College, York, and at Cambridge University. He worked as a journalist, and was elected to Parliament in 1970.

Tughluq, Muhammad bin (1290-1351), was the second sultan of the Tughluq dynasty. The dynasty ruled briefly over most of the Indian subcontinent. Tughluq was born in Delhi. He displayed great intelligence as a child, and showed early promise of being a warrior. He grew up to be a cultured, tolerant visionary, but was also capable of great cruelty.

Tughluq made radical attempts to establish an Islamic state within secure borders. In 1327, he moved the capital and many of its inhabitants from Delhi to Deogir (now Daulatabad), about 1,000 kilometres to the south. He hoped this move would strengthen his hold on newly conquered territories. But the experiment was not successful. His attempt to introduce tokens instead of money also failed. He sent unsuccessful expeditions against Khorasan in Iran, and against the Chinese-dominated northern hill states. But he improved agriculture by means of irrigation and crop rotation. In 1351, Tughluq was killed suppressing a rebellion in Sind.

Tui is the name of one of New Zealands finest songbirds. It is a type of honeyeater, about 30 centimetres long, that looks like a starling. The plumage is green with purplish reflections. Below the black throat are two tufts of white-circled feathers. Tuis eat fruit, insects and nectar, mainly in forests, but also visit suburban areas to feed. The tui is an excellent mimic of other birds.

Scientific classification. The Tui belongs to the honeyeater family, Meliphagidae. It is *Prosthemadura novaeseelandiae.*

Tuileries, a famous royal palace, stood on the right bank of the Seine River in Paris. During the French Revolution, mobs forced Louis XVI and his family to live there instead of at Versailles. In 1792, the mobs killed Swiss guards who tried to defend the royal family at the Tuileries. For a time, the Convention of the Revolution held its sessions in the Tuileries. Napoleon made it his home, and it was the royal residence after the Restoration.

Catherine de Médicis began the building of the palace in 1564, but it was not completed until the 1600's. It formed a long, narrow band of buildings with high roofs and dormer windows. At one end it joined the Louvre. The famous Tuileries Gardens covered 30 hectares on the west side of the palace. Supporters of the Commune destroyed most of the palace in 1871, but the garden is still popular.

Tularaemia, also called rabbit fever, is an infectious disease of many mammals, including human beings. Tularaemia is caused by a bacterium, *Francisella tularensis.* It was first reported in Tulare County, California, U.S.A., in 1911, and is known to exist worldwide. Tularaemia is most often transmitted by the bite of a tick or some other insect. Human beings also can catch this disease by handling infected animals, such as squirrels, rabbits, and rats. Tularaemia causes a fever that comes and goes, and lasts several weeks. The lymph glands become swollen around the bite. If not treated, tularaemia often causes death. Treatment is with antibiotics.

Tulip is a lovely, graceful garden flower that originated in southern Europe and Asia. Although tulips grow in many parts of the world, we generally associate them with the Netherlands.

Tulips are colourful garden flowers that bloom in the spring. Tulip leaves and the flower stem grow directly out of a bulb.

Tulips bloom in spring. They grow from bulbs, and the leaves, stems, and flowers grow directly out of the bulb. The stems range from about 10 centimetres to more than 75 centimetres tall. The tulip usually develops only one large, bell-shaped flower at the tip of its stem. But there are types with more than one stem or flower. The flowers usually grow erect on the stem. They may be almost any solid colour, and some tulips have flowers with two colours. In addition, the flowers of some tulips become streaked with other colours because of virus diseases that affect the plant's colour but not its health.

Gardeners plant tulip bulbs in autumn. They require a well-drained, loamy soil of average richness. Usually only professional tulip growers or plant breeders grow the flowers from seed, because tulip seed does not produce a flowering bulb for four to seven years.

Thousands of varieties of tulips have been developed from a few *species* (kinds). Almost all the cultivated kinds of tulips were developed from tulips of Asia Minor that were brought to Vienna from Constantinople (now Istanbul) in the 1500's. The name *tulip* comes from a Turkish word which means *turban.* The beautiful blossoms look a little like turbans. Popular garden varieties of tulips include the Darwin hybrids and the Triumphs, Lily-flowered, Fringed, and Parrot tulips.

After the tulip was brought to Europe, it became the most fashionable flower in both England and Holland. Interest in the flower developed into a craze in Holland, called the *tulipomania,* between 1634 and 1637. Individual bulbs sold for huge prices. People invested their money in tulips in the same way that business people might invest in high-technology stocks. Many people lost fortunes in the tulip market, and finally the government was forced to regulate the trade in bulbs.

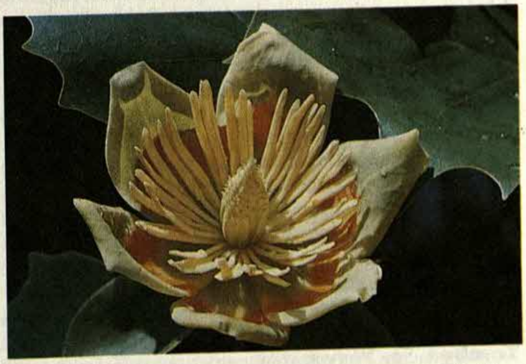
Tulip cultivation is an important industry in the Netherlands today. Billions of bulbs are produced every year. Dutch growers produce nearly 2,000 varieties. About 400 of these are available in large quantities.

Scientific classification. Tulips belong to the lily family, Liliaceae. The tulip brought to Europe in the 1500's is *Tulipa gesneriana.*

See also **Flower** (picture: Garden perennials [Bulbs]); **Netherlands** (picture: The Polders)

Tulip tree, also called *yellow poplar* and *tulip poplar,* is the tallest broadleaf tree in the eastern United States. In forests, it may grow to over 60 metres high, and its trunk may be 1.5 to 3 metres thick at the base. It grows from southern New England to Florida and westward to southeast Missouri and Louisiana.

The showy greenish-yellow blossoms of the tulip tree resemble tulips and are an important source of nectar for bees. Its distinctive leaves have a broad notch at the tip and two or four lobes. They are smooth, long-stalked, and graceful. The leaves turn butter-yellow in autumn. The *sapwood* (outer wood) is whitish. The *heartwood* (inner wood) is sunshine-yellow to pale-tan. The wood is easily worked and is used chiefly for furniture, veneer, boxes, and baskets.



A tulip tree blossom resembles the flower of a tulip. The blossoms are an important source of nectar for bees.

Scientific classification. The tulip tree belongs to the magnolia family, Magnoliaceae. It is *Liriodendron tulipifera.*

See also **Tree** (Familiar broadleaf and needleleaf trees [picture]).

Tull, Jethro (1674-1741), an English farmer, built the first practical farm tool for planting seeds in rows. In Tull's day, farmers sowed seed by hand. This practice wasted seed and produced an uneven yield. European inventors had experimented with a mechanical seeding device, but none achieved Tull's success. About 1700, Tull developed a mechanical seed *drill,* which made rows of small trenches in the soil and dropped seeds in them. His horse-drawn seed drill planted three rows at a time and used less seed than did sowing by hand. This device marked the first step toward the mechanization of British agriculture.

Tull was born in Berkshire, England. He attended Oxford University and studied law at Gray's Inn in London. He travelled widely in Europe to observe agricultural practices. Tull described and illustrated his seed drill in his book *Horse-Hoeing Husbandry* (1731).

See also **Agriculture** (The invention of new farm equipment).

Tully Falls, at the head of the Tully River in north Queensland, Australia, is a steep waterfall filled by a runoff from more than 2,500 millimetres of summer rainfall from November to March. The falls are 288.5 metres high. Hydroelectric power generated by the falls supplies power for the towns of Cairns and Townsville. The power stations, 16 kilometres downstream at Kareeya, were completed in 1959.

Tulsa (pop. 367,302; met. area pop. 708,954) is a major centre of the United States petroleum industry. It lies along the Arkansas River in northeastern Oklahoma, and serves as Oklahoma's busiest port and its chief manufacturing centre.

Tulsa has more than 1,000 manufacturing plants. The chief industries manufacture fabricated metal products and nonelectric machinery. Oklahoma's largest oil refinery stands just outside the Tulsa business district. The city's population almost doubled between 1950 and 1980.

Tumbleweed is the popular name for several plants that grow in the prairie and plains regions of the United States. These plants develop rounded tops, and in autumn they wither and break off at ground level. The dried plants are then carried or tumbled about by the wind, like great, light balls. As they move, they scatter their seeds over the plains. These plants are considered great pests by farmers and ranchers. Tumbleweeds often pile up against barbed-wire fences or fill small gullies. The common tumbleweeds include the *Russian thistle* and an amaranth known as pigweed. The Russian thistle gets its name from the fact that it was introduced to the United States from Russia as flaxseed in 1873. All tumbleweeds are *annuals*—that is, they grow from seed to maturity and then die within one year.

Scientific classification. The Russian thistle is in the goosefoot family, Chenopodiaceae. It is *Salsola kali.* Pigweed belongs to the family Amaranthaceae. It is *Amaranthus albus.*

Tumboa. See **Welwitschia.**

Tumour is an abnormal growth of tissues in the body. Tumours are also called *neoplasms.* Some tumours are *benign* (noncancerous). They limit themselves to a certain region and do not spread elsewhere in the body. Once benign tumours are removed, they usually do not grow again. *Malignant tumours* (cancers) that are not completely removed can spread throughout the body, often destroying other tissues in the body (see **Cancer** [How cancer develops]). When cancer arises from the skin, tissues that line the body cavities, or nonblood-forming organs, it is called *carcinoma.* Cancer that affects bones, cartilages, and soft tissues is called *sarcoma. Leukaemia* is cancer of the bone marrow or other blood-forming organs. Only a doctor can determine whether a tumour is benign or malignant.

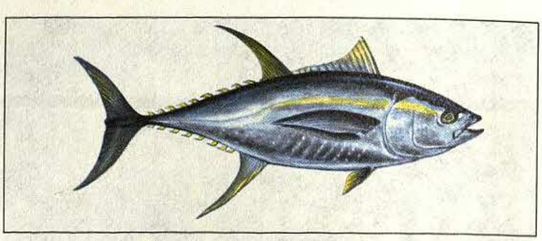
Tumours may grow from any kind of tissue in the body. They may develop in the skin, in muscles, nerves, blood vessels, bones, or any organ. A well-known tumour is the mastoid tumour, which grows over the mastoid process just behind the ear (see **Mastoid**).

Tumours are often named after the tissue from which they grow. For example, a *lipoma* is a benign tumour made up of *lipid* (fat) tissue. *Gliomas* are made up of *glia,* the peculiar branched cells that support the nerves. *Lymphoma* is a malignant tumour of lymphoid tissue.

Related articles in *World Book* include:

Biopsy
Cancer
Epithelioma
Leukaemia
Malignancy
Mole
Neurofibromatosis

Tumpline. See **Indian, American** (Family life [Transportation]).



The yellowfin tuna provides light meat for canning.

Tuna is any of 13 species of saltwater fish in the mackerel family. Tuna meat is a popular food in many countries and is sold canned, fresh, and frozen. The United States and Japan are the chief consumers of tuna. The tuna is also a leading game fish. The most important commercial types of tuna are the *albacore, bigeye, skipjack,* and *yellowfin.*

The largest tuna is the *bluefin,* which grows up to 3 metres long and weighs up to 680 kilograms. The smallest tuna is the *bullet mackerel,* which grows to over 50 centimetres long and weighs up to about 2.5 kilograms.

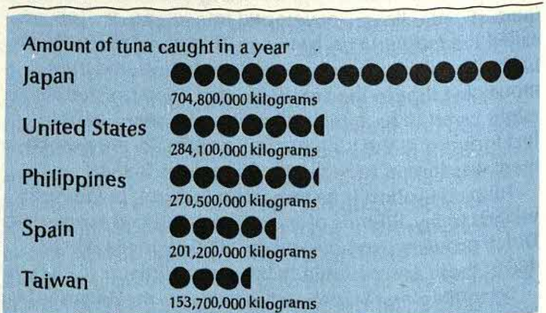
Tuna rank among the swiftest fish. The bluefin can swim as fast as 70 kilometres per hour. Like other fish, the tuna has gills that take oxygen from the water passing over them. But unlike most fish, the tuna cannot pump water over its gills. Therefore, it must swim continuously in order to breathe.

Tuna live in temperate and tropical ocean waters. In summer, they range as far north as Newfoundland, in Canada, and Norway in the Atlantic Ocean, and British Columbia and Northern Japan in the Pacific Ocean. Major tuna fisheries operate in the Atlantic, Pacific, and Indian oceans.

Tuna sometimes migrate long distances. One bluefin, tagged and released off Japan, was recaptured off the Pacific coast of northern Mexico. This fish had swum at least 10,800 kilometres to reach its destination.

Tuna are caught in three main ways. In *bait fishing,* crews throw live bait overboard to attract the tuna and then catch them by hooks and lines attached to long poles. In *longlining,* tuna are caught with a line that is up to 130 kilometres long and has as many as 2,200 shorter lines with baited hooks. *Purse seining,* the chief method of catching skipjack and yellowfin tuna, encircles the fish in large nets called *purse seines.* In the east-

Leading tuna-fishing countries



Figures are for 1987. Sources: *Fisheries Yearbook, Taiwan Area, 1987,* Taiwan Fisheries Bureau; *Yearbook of Fishery Statistics, 1987,* Food and Agriculture Organization of the United Nations.

Tuna may be caught in large nets called *purse seines.* This photograph shows members of a fishing crew with a catch of skipjack tuna, one of the most important commercial types of tuna.

ern Pacific, crews locate yellowfin tuna by seeking schools of dolphins, which often swim above the fish. Many dolphins have been trapped with the tuna and accidentally killed. Some countries require the nets to have escape chutes for dolphins. In 1990, major American producers of canned tuna announced they no longer would accept fish caught in nets that also kill dolphins.

Scientific classification. Tuna belong to the mackerel family, Scombridae. The scientific name for the albacore is *Thunnus alalunga;* the bigeye is *T. obesus;* the yellowfin is *T. albacares;* and the bluefin is *T. thynnus.* The skipjack is *Katsuwonus pelamis,* and the bullet mackerel is *Auxis rochei.*

See also **Fish** (picture: Fish of coastal waters [Bluefin tuna]); **Fishing industry** (Where fish are caught).

Tuna, a fruit. See **Prickly pear.**

Tunbridge Wells (pop. 98,300) is a local government district and residential town in southwestern Kent, England. Agriculture is the main industry of the district. Grain crops are important, but sheep and cattle are also reared. The town of Tunbridge Wells has an industrial estate, with products including aerosols, books and printed materials, and sunglasses. Many people who live in the district work in London.

Tunbridge Wells town was at one time a fashionable spa, visited by royalty. The town is known for its terraced promenade, called *The Pantiles.* The Pantiles consists of shops set behind a colonnade and a row of lime trees. See also **Kent.**

Tundra is a cold, dry region where trees cannot grow. Tundras are covered by snow for more than half the year. The long, cold winters and short, cool summers prevent the growth of trees in a tundra. But mosses, lichens, grasses, low shrubs, and grasslike plants called *sedges* grow in a tundra, and many kinds of animals live there. There are two kinds of tundras, *Arctic* and *Alpine.*

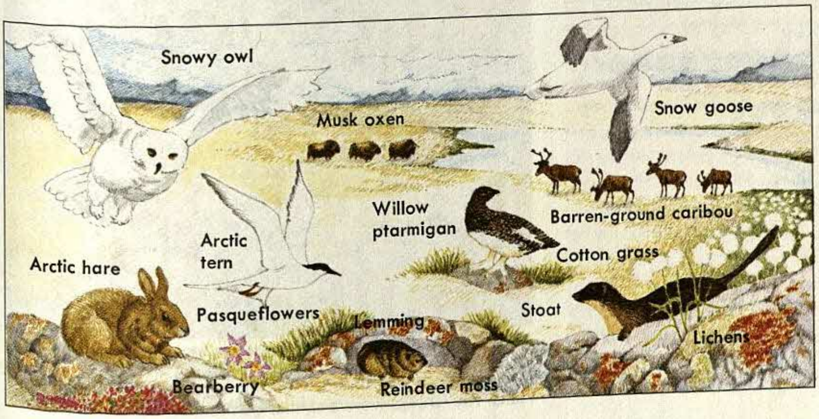
Arctic tundras are found near the Arctic Ocean, in Greenland and the northern parts of Alaska, Canada, Europe, and Russia. Most are lowlands with many lakes, but some have mountains. Few people live in Arctic tundras, but some Eskimos live in areas where they can fish and hunt for food (see **Eskimo**).

Each spring, tundras come to life. Geese, terns, and other birds fly north to nest. The tundra plants grow rapidly and cover the ground with bright flowers. Caribou, reindeer, and musk oxen graze on these plants, and wolves prey on the grazing animals. Other tundra wildlife includes Arctic foxes and hares, grizzly bears, lemmings, polar bears, and ptarmigans. Seals and walruses live along the coastlines. Arctic char and a few other kinds of fish live in the lakes and rivers. Mosquitoes, black flies, and other insects thrive.

Summer temperatures in an Arctic tundra range from about 3° to 12° C. The soil remains permanently frozen from about 30 to 150 centimetres below the surface of the ground. This permanently frozen soil, called *permafrost,* prevents water from draining away. As a result, most of the soil stays cold and wet throughout the summer.

Most of the precipitation in Arctic tundras comes from snow, which covers the ground from September to April or May. In the autumn, caribou, reindeer, and most birds of the Arctic migrate south to winter feeding grounds. The other animals remain active in the tundra throughout the winter.

Arctic tundras have large deposits of coal, natural gas, oil, iron ore, lead, and zinc. The coal, oil, and natural gas can help meet the world's demands for fuel. Special pipelines were designed to transport the oil and gas with the least possible damage to the environment of the tundras.



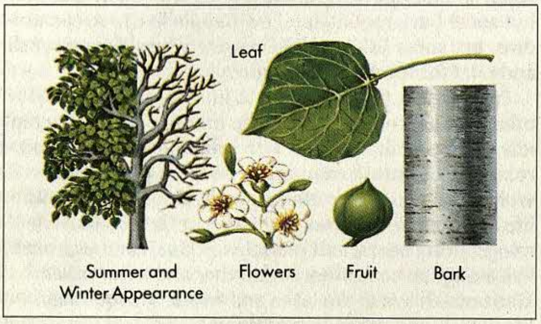
Many living things inhabit the Arctic tundra. Lichens, mosses, and bright flowers cover the ground in summer. Each autumn, Arctic hares, ermines, willow ptarmigans, and other tundra animals grow white winter coats. These white coats blend with the snow and help protect the animals from their enemies.

Alpine tundras are on mountains throughout the world at elevations too cold for trees to grow. Permafrost rarely occurs in alpine tundras, and most of these regions have well-drained soils. Deer, mountain goats, and various species of sheep graze on alpine tundras during the summer. Pikas, ptarmigans, marmots, and many kinds of insects also live in alpine tundras.

See also **Arctic; Biome** (map); **Permafrost.**

Tundra wolf. See **Wolf.**

Tung oil is an oil that comes from the seed kernels of the tung tree. The tung tree originally grew in East Asia, chiefly in China. Tung oil is also called *China-wood oil, Japanese-wood oil,* or simply *wood oil.* Tung oil is one of the most powerful drying agents. The oil resists acids, alkalis, and alcohols.



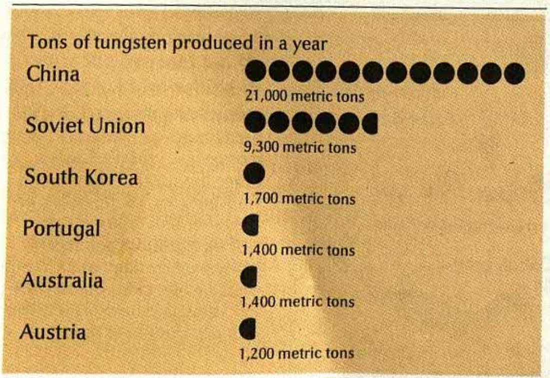
The tung tree is the source of tung oil.

Tung oil is widely used in paints, lacquers, varnishes, and printing inks. Paints containing tung oil help seal the underwater surfaces of swimming pools, dams, piers, and boats. Varnishes made with it help insulate wire and metallic surfaces. Tung oil is used to waterproof paper and fabrics, and as a finish for wood. Because of its relatively high cost, tung oil is sometimes replaced with epoxy resins and other synthetics.

Scientific classification. The tung tree belongs to the spurge family, Euphorbiaceae. It is *Aleurites fordii.*

Tungsten, also called *wolfram,* is a chemical element with the symbol W. It is a moderately hard, silver-white metal. Tungsten has many uses. It has the highest melting point of all metals, and remains strong at very high temperatures. For these reasons, it is used in equipment that must withstand high temperatures. Tungsten is added to steel to make steel harder, stronger, and more elastic. Tungsten steel tools last longer than ordinary steel tools. Tungsten and carbon form tungsten carbide, an extremely hard substance used in the tips of high-speed cutting tools, and in mining and petroleum drills.

Leading tungsten-mining countries



Figures are for 1989, prior to the breakup of the Soviet Union.
Source: U.S. Bureau of Mines.

Tungsten is widely used in the electronics industry. It is made into heating filaments for vacuum tubes used in television sets and other electronic equipment. It is also used to make filaments for electric lights and contact points for the ignition systems of cars. Compounds of tungsten with either calcium or magnesium are *phosphors* (chemicals that give off light). They are used in fluorescent lamps. Mixtures of alkali metals with different amounts of tungsten form *tungsten bronzes,* which are used in the paint industry.

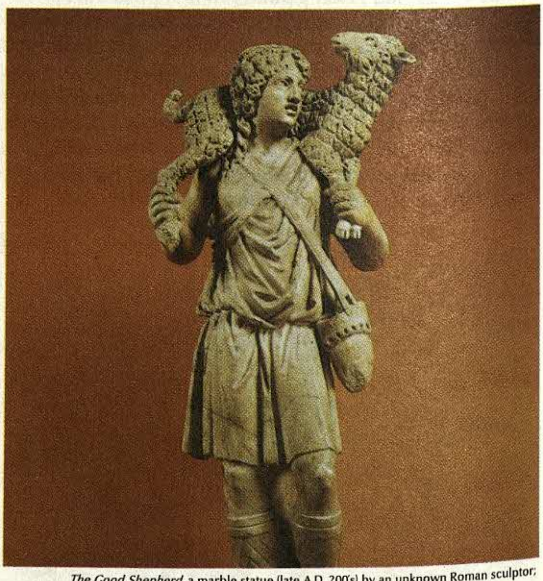
Tungsten occurs in nature in the minerals scheelite (calcium tungstate, $CaWO_4$) and wolframite (ferrous-manganous tungstate, $[Fe,Mn] WO_4$). China is the leading tungsten-mining country. Tungsten is prepared from the minerals by first adding sodium hydroxide to convert the insoluble tungsten compounds into a solution of sodium tungstate (Na_2WO_4). Acid is then added to make tungstic trioxide (WO_3) come out of the solution. Tungstic trioxide is heated with hydrogen to form the pure metal.

The atomic number of tungsten is 74 and its atomic weight is 183.85. Tungsten melts at about 3400 °C and boils at about 5600 °C. It was discovered in 1783 by two Spanish chemists, Fausto de Elhuyar and his brother Juan José.

See also **Alloy** (Alloys of iron); **Element, Chemical** (tables); **Wolframite; Electric light** (The filament).

Tungsten carbide. See **Tungsten.**

Tunic is a loose, short garment, reaching from the neck to about the knee. It is usually fastened at the



The Good Shepherd, a marble statue (late A.D. 200's) by an unknown Roman sculptor; Museo Pio Christiani, the Vatican, Vatican City

The tunic was a short, loose garment worn by the ancient Romans. The Greeks wore a similar garment called a *chiton.*

waist by a belt. The name comes from the Latin word *tunica.* The tunica was a garment worn by people of ancient Rome. The men covered it with the *toga,* and the women with the *palla.* Greek men and women wore a similar garment called the *chiton.* In the Middle Ages, Europeans wore tunics called *surcoats.* Tunic dresses and shirts have also been popular in the 1900's.

Tunic, or *tunicle,* also means a robe worn by a subdeacon of the Roman Catholic and some Episcopal churches during Mass.

See also **Clothing** (Ancient times); **Toga.**

Tunicle. See **Tunic.**

Tuning. See **Radio** (The tuner); **Television** (Tuner).

Tuning fork is a device used for tuning musical instruments and for finding a standard pitch. It is made of metal and shaped like a U with a handle on the bottom.

A tuning fork produces a tone when struck. The tone is not affected by moisture and most other conditions that affect musical instruments. However, the tone is slightly affected by variations in temperature. The forks are made for any note of the scale, but those most often used are A, B flat, or the C above middle C. John Shore, an English trumpeter, is said to have invented the tuning fork in 1711. Today, electronic devices are also used to tune musical instruments.

See also **Sound** (pictures).

Tunis (pop. 596,654) is the capital and largest city of Tunisia. Tunis lies on the western shore of the Lake of Tunis, a shallow lagoon linked to the Mediterranean Sea by a narrow channel. For the city's location, see **Tunisia** (map). In addition to serving as the governmental centre of Tunisia, Tunis is the headquarters for most of the country's banks and insurance companies. The Tunis area is Tunisia's chief industrial centre. The main industries are food processing and textile manufacturing. Commerce and tourism also play important roles in the economy.

Tunis consists of an old and a modern section. The old section, called the *medina,* is a crowded area with narrow, winding streets. The modern section has Western-style buildings and broad, tree-lined boulevards.

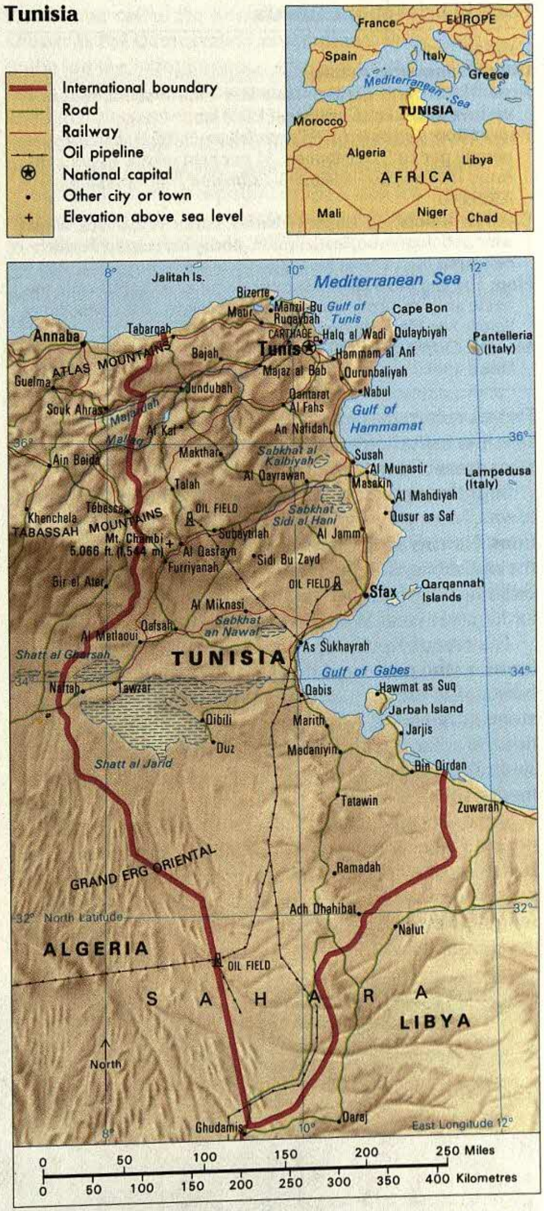
Thynes, a settlement on the site of present-day Tunis, was part of the ancient empire of Carthage. The settlement gradually developed into the city of Tunis. Arab Muslims captured Tunis in A.D. 698. From the early 1200's to the late 1500's, Tunis was a centre for trade between Africa and Europe. Today several international organizations, including the Arab League, have their headquarters in Tunis.

Tunisia extends farther north than any other country in Africa. Its northern tip is only 137 kilometres from Sicily, Italy, a part of Europe. Both northern and eastern Tunisia border the Mediterranean Sea.

Tunisia is part of the Arab world, the Mediterranean area, and Africa. Almost all Tunisians speak Arabic and follow an Arab way of life. For hundreds of years, trade routes have connected Tunisia to Africa south of the Sahara. France controlled Tunisia from 1881 until Tunisia became independent in 1956. Tunisia shows many French influences. Tunis is its capital and largest city.

Government. Tunisia is a republic headed by a president. The people elect the president to a five-year term. The president appoints a Cabinet headed by a prime minister to assist him. Tunisia has a one-house legislature called the National Assembly. The people elect the 163 members of the National Assembly to five-year terms. All people who have been citizens for five years and who are 20 or older may vote. The president appoints the governors of Tunisia's 13 provinces.

Tunisia



Tunisia has several political parties. The Democratic Constitutional Rally is by far the largest. It has controlled the government since Tunisia became independent.

People. For Tunisia's total population, see the *Facts in brief* table with this article. Life in Tunisia is more uniform than it is in most other African and Middle Eastern countries. This is chiefly due to the people's similarity in language and religion, and to the fact that political and cultural life is centred in one city, Tunis.

Small groups of Europeans, Jews, and Berbers live in Tunisia. But almost all Tunisians are Arabs and Muslims.

Facts in brief about Tunisia

Capital: Tunis.
Official language: Arabic.
Area: 163,610 km². *Greatest distances*— north-south, 780 km; east-west, 378 km. *Coastline*— 1,028 km.
Population: *Estimated 1996 population*—9,095,000; density, 54 people per km²; distribution, 54 per cent urban, 46 per cent rural. *1984 census*—6,966,173. *Estimated 2001 population*—9,929,000.
Chief products: *Agriculture*—barley, citrus fruit, olives, wheat, wine. *Mining*—iron, lead, lignite, phosphates, zinc. *Forestry*—oak, pine.
Flag: The flag has a large white circle on a red field. Inside the circle are a red crescent and star, emblems of the Muslim religion. See **Flag** (picture: Flags of Africa).
Money: *Currency unit*—Tunisian dinar. One dinar = 1,000 millimes.

French culture has influenced several features of Tunisian life, including architecture and food. Many Tunisians speak French as a second language.

Slightly more than half the people live in cities or towns. Most cities are divided into old and new sections. Narrow streets and covered markets characterize the old sections. Tree-lined avenues and European-style buildings are typical of the new sections. Many people in the cities wear Western-style clothes.

The rest of Tunisia's people live in villages or on farms. In the past, rural dwellings included many mud huts and tents. But today, most rural houses are made of stone or concrete. Many people in the rural areas continue to wear traditional Arab clothing—a turban or skullcap, and a long, loose gown, or a long coatlike garment with long sleeves.

Since the mid-1950's, the Tunisian government has devoted an average of one-fifth of its budget to education. Almost all primary school-age children and about one-third of secondary school-age children attend school. The country's higher education system includes the University of Tunis and professional schools.

Land. The uniformity of Tunisian life is also partly due to the country's geography. Two branches of the Atlas mountain range, which crosses northwestern Africa, extend into Tunisia. In Tunisia, the northern branch is called the Atlas Mountains, and the southern branch, the Tabassah Mountains. But the mountains are low. Few peaks reach more than 600 metres, and the highest, Mount Chambi, is just 1,544 metres above sea level. Unlike neighbouring Algeria and Morocco, Tunisia has no hard-to-reach mountain regions which would cut the people off from the influences of the cities and plains.

Hills and grassland lie between the mountain ranges. Much of Tunisia's wheat is grown in the Majardah River valley in the north. The Majardah is the only river in Tunisia that does not dry up in summer.

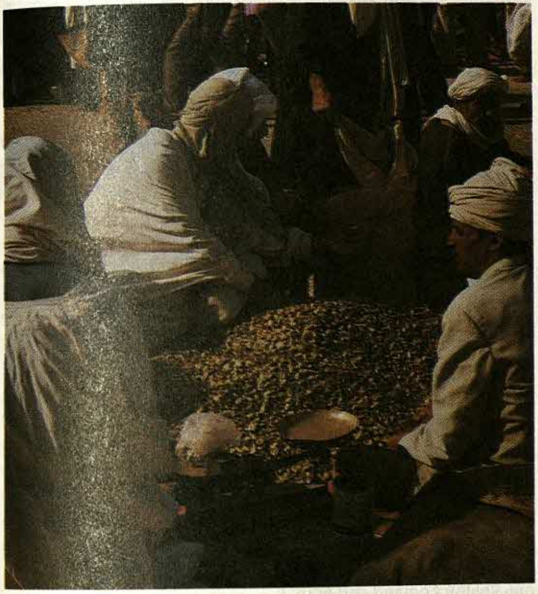
From the Tabassah range, the land descends across a plateau to the Sahara in the south and to a coastal plain in the east. The plateau is covered with coarse grass. The people raise cattle, sheep, and goats. The southern desert contains great salt lakes and date palm oases.

The fertile coastal plain extends along the east coast from Sfax to Tunis. Cereals, citrus fruit, and olives are grown there. This region also has Tunisia's largest towns and cities.

Tunisia has hot, dry summers and warm, wet winters. The average temperatures are 26 °C in summer and 11 °C in winter. In the north, most rain falls in winter, but it is irregular and droughts occur every three or four years. There is little rain in the south.

Economy. Tunisia is a leading producer of phosphates. It also has petroleum resources that are used for its own needs and for export. Phosphates and petroleum account for about half the value of Tunisia's exports. Food processing and the manufacture of basic consumer goods account for most of the country's industrial production. Wheat, barley, grapes for wine, olives, olive oil, and dates are Tunisia's chief farm products. Tourism also contributes to the economy.

Tunis, the capital and largest city of Tunisia, is the nation's political and cultural centre. The building that houses the nation's Finance Ministry stands in the foreground, overlooking a tree-shaded square.



At a Tunisian market place, people meet to buy and sell various commodities. In the picture above, merchants are weighing quantities of nuts and selling them to shoppers.

Most of Tunisia's major cities, industries, and fertile land are in the north and east. These regions are richer than the dry, less developed south. Although Tunisia is not rich in natural resources, it does have a more balanced economy than many of its neighbours.

Tunisia has a good road and rail system. Tunisia's chief ports are Tunis, Halq al Wadi, Bizerte, Susah, and Sfax. Oil and gas are shipped from As Sukhayrah.

History. People and ideas have entered northwest Africa through Tunisia for centuries. The Phoenicians began the Carthaginian Empire in Tunisia about 1100 B.C. According to tradition, the famous city of Carthage was founded near present-day Tunis in about 814 B.C. The Romans defeated Carthage in 146 B.C., and ruled Tunisia for the next 600 years. In A.D. 439, the Vandals, a European tribe, invaded Tunisia, defeated the Romans, and captured Carthage. They ruled the region for almost 100 years. The Byzantines, from Constantinople (now Istanbul), ousted the Vandals in 534.

The Byzantines had loose control over Tunisia when Muslim Arabs from the Middle East invaded in the mid-600's. Tunisia then began to become slowly a part of Arab-Muslim civilization. The Ottoman Empire, which was centred in Asia Minor (now Turkey), won control of Tunisia in 1574. The Ottoman rulers appointed a *bey* (ruler) to govern Tunisia from Tunis. Tunisia was technically part of the Ottoman Empire until after World War I ended in 1918, but by the 1700's the beys in Tunis had achieved a large measure of independence.

In 1881, France imposed a protectorate over Tunisia. It controlled Tunisia's financial, foreign, and military affairs, leaving the bey only minor authority.

A Tunisian independence movement started before World War I began in 1914, but the most successful movement did not begin until 1934. In that year, Habib Bourguiba founded the Neo-Destour (New Constitution) Party—later called the Socialist Destour Party and now known as the Democratic Constitutional Rally. Bourguiba led the independence struggle for more than 20 years. Tunisia gained internal self-government in 1955, and full independence in 1956. In the late 1950's and early 1960's, France, at Tunisia's demand, withdrew its troops from Tunisia and gave up its Tunisian bases.

Tunisia became a republic in 1957, and the people elected Bourguiba president. Bourguiba was reelected in 1959, 1964, and 1969. In 1975, he was named president for life. His government introduced many social and economic reforms. It gave voting rights to women and set up a national school system.

Tunisia has experienced enormous changes since gaining independence. But some of its successes have created new problems. The number of Tunisians who receive an education has increased greatly, but many of the educated people cannot find jobs that require their skills. Tourism provides income and jobs, but some people fear that the influence of tourists may cause the country to lose its Arab-Muslim heritage.

A growing number of Tunisians became dissatisfied with Bourguiba's domination of politics. From 1963 to 1981, Bourguiba's party was Tunisia's only legal political party. In 1987, Prime Minister Zine el-Abidine Ben Ali removed Bourguiba from office. Ben Ali, a member of Bourguiba's party, claimed Bourguiba had become incapable of handling the presidency. Ben Ali then became president. In 1989, and again in 1994, he was elected president without opposition.

See also **Arab League; Bourguiba, Habib; Carthage; Olive; Tunis.**

Tunnel is an underground passageway. Tunnels are dug through hills and mountains, and under cities and waterways. They provide roads and railways with convenient routes past natural and artificial obstacles. Tunnels are used in mining to reach valuable minerals deep within the earth. They also carry large volumes of water for hydroelectric power plants. Some tunnels provide fresh water for irrigation or drinking, and others transport wastes in sewer systems.

How tunnels are built

Some tunnels are driven through the hard rocks of hills or mountains, or they are dug through soft earth. Others are buried in the ground under a body of water. Engineers study the material through which they intend a tunnel to pass in order to determine the kinds of methods and equipment to use in its construction.

Rock tunnels. Rock offers the greatest resistance to tunnelling. The construction of most rock tunnels involves blasting. In order to blast rock, workers first move a large scaffold next to the tunnel *face* (front). A drilling machine called a *jumbo* is mounted on the scaffold and several drills are used to bore holes about 2 to 3.5 metres into the rock. The holes, which measure only a few centimetres in diameter, are packed with explosives. After these charges are exploded and the fumes sucked out, the pieces of rock, called *muck,* are carted away. If the tunnel is through strong, solid rock, it may not require extra support for its roof and walls. Most rock tunnels, however, are built through rock that is naturally broken by joints, or contains pockets of fractured rock. Workers prevent this weak rock from falling by erecting rings of steel beams, timbers, or other supports before blasting the next section. In most cases, a permanent lining of concrete is added later.

Some tunnels are built in soft, but firm rock such as limestone or shale. These tunnels are dug by tunnel-boring machines. A circular plate covered with *disc cutters* is attached to the front of these machines. As the plate slowly rotates, the disc cutters slice into the rock. Scoops on the machine carry the muck to a conveyor that removes it to the rear.

Earth tunnels include tunnels that are dug through clay, silt, sand, or gravel, or in a muddy riverbed. Tunnelling through such soft earth is especially dangerous because of the threat of cave-ins. In most cases, the roof and walls of a section of tunnel dug through these materials are held up by a steel cylinder called a *shield.* The shield is left in place while workers remove the earth inside it and install a permanent lining of cast iron or precast concrete. Then jacks push the shield into the earth ahead of the tunnel, and the process is repeated. Some tunnel-boring machines have a shield attached to them and are able to position sections of concrete tunnel lining into place as they dig.

Tunnelling through the earth beneath bodies of water adds the danger of flooding to that of cave-ins. Engineers generally prevent water from entering a tunnel during construction by compressing the air in the end of the tunnel where the work is going on. When the air pressure inside the tunnel exceeds the pressure of the water outside, the water is kept out. This method was used to build the subway tunnels under the River Thames in London and the East River in New York City.

A tunnel-boring machine, was used to dig the Channel Tunnel, linking England and France.

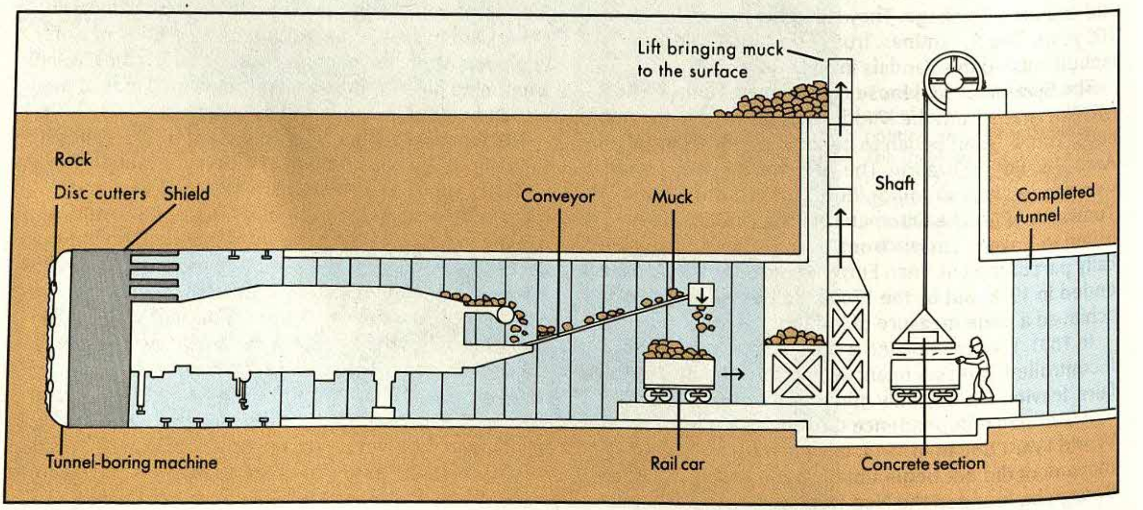
Immersed tunnels are built beneath bodies of water. They are generally less expensive to build than those dug by the shield or compressed-air methods. Construction of an immersed tunnel begins by dredging a trench across the bottom of a river, bay, or other body of water. Closed-ended steel or concrete tunnel sections are then floated over the trench and sunk into place. Next, divers connect the sections and remove the ends, and any water in the tunnel is pumped out. In most cases, the tunnels are then covered with earth. The Hong Kong Cross Harbour tunnel is an immersed tunnel.

Kinds of tunnels

Tunnels are often classified according to their use. There are four main types: (1) railway tunnels, (2) road tunnels, (3) water tunnels, and (4) mining tunnels.

Railway tunnels. Many great engineering feats were performed in building the railways of Europe and North America. The greatest of these involved the boring of long tunnels through the rocks of the Alps, in Europe, and of the Rocky Mountains, in North America. Such

How a tunnel is constructed A tunnel-boring machine digs into rock with attachments called *disc cutters.* The broken rock, called *muck,* then is removed by conveyor and rail car and brought to the surface in a lift. Meanwhile, concrete sections of the tunnel lining are lowered through a shaft. A shield on the tunnel-boring machine holds up the roof until workers can erect a new section of tunnel lining.



tunnels reduce travelling time and increase the efficiency of trains. The steeper a locomotive must climb, the less weight it can pull. The steepest grade along a railway line determines the size of load a train can haul. Tunnels through mountains reduce steep grades and thus allow trains to haul more goods and people at less cost. For example, the Moffat Tunnel near Denver, Colorado, U.S.A., completed in 1927, reduced the altitude to which locomotives had to climb by 730 metres.

Road tunnels provide routes for cars, trucks, and other road vehicles. Such tunnels are specially built to provide for the removal of exhaust fumes. For example, the Holland Tunnel, which is situated under the Hudson River and which links New York City and New Jersey, U.S.A., uses electric fans for ventilation. The giant fans are housed in four 10-storey towers on the shore. These fans completely change the air in the tunnel every 90 seconds. They pump fresh air into the tunnel through ventilators in the road and suck exhaust fumes out through ventilators overhead. Many road tunnels are also equipped with lights and special monitoring systems that help prevent traffic jams.

Water tunnels. Many tunnels provide water to city waterworks, to hydroelectric power plants, or to farms for irrigation. Others carry storm drainage or sewage. Most water tunnels measure about 1.5 metres or more in diameter, and they have smooth linings that help the water flow. Tunnels carrying water to hydroelectric power plants must be strong enough to withstand extremely high water pressures.

Mine tunnels are made by blasting or by tunnelling machines. Mine shafts are not lined, but they may have supports. Most of the tunnels in mines are open only at one end.

World's longest railway tunnels

Tunnel	Location	Length in kilometres	Year opened
Seikan	Japan	53.9	1988
Channel	England-France	49.2	1994
Oshimizu	Japan	22.2	1982
Simplon I, II	Italy-Switzerland	19.8	1906, 1922
Shin Kanmon	Japan	18.7	1975
Apennine	Italy	18.5	1934
Rokko	Japan	16.3	1972
Furka Base	Switzerland	15.4	1982
Haruna	Japan	15.4	1982
St. Gotthard	Switzerland	15.0	1882

World's longest motor-traffic tunnels

Tunnel	Location	Length in kilometres	Year opened
St. Gotthard Road	Switzerland	16.3	1980
Arlberg	Austria	14.0	1978
Fréjus	France-Italy	13.0	1980
Mt. Blanc	France-Italy	11.7	1965
Gran Sasso	Italy	10.0	1976
Seelisberg	Switzerland	9.3	1980
Ena	Japan	8.5	1976
Rokko II	Japan	6.9	1974
San Bernardino	Switzerland	6.6	1967
Tauern	Austria	6.4	1974

History

About 15,000 years ago, prehistoric people in Europe used picks made of deer antlers and horse bones to dig tunnels for mining flint, which they used for making tools and weapons. By about 3500 B.C., people had learned to fracture rock at a tunnel face by building fires in front of it. Ancient Egyptians built tunnels for mining metals and storing water, and as approaches to tombs.

There were few developments in tunnel-building techniques until the A.D. 1600's, when gunpowder began to be used to blast through hard rock. The rise of railways during the 1800's was accompanied by a great increase in tunnel building and the invention of several devices to aid in such construction. In 1825, a tunnel shield invented by Marc Isambard Brunel, a French-born engineer, was used for building a railway tunnel under the River Thames in London. This tunnel, which was completed in 1843, was the first railway tunnel to be built under a navigable river. The 15-kilometre St. Gotthard railway tunnel, dug through the Swiss Alps between 1872 and 1882, was the first major tunnel to be built using dynamite and drills.

In the early 1900's, tunnel building was greatly speeded up through the invention of faster and lighter drills, harder drill bits, and mechanical muck loaders. A tunnel-boring machine was first used in 1882, when the United Kingdom began work on a tunnel under the English Channel. This machine dug at a rate of about 12 metres in 24 hours. It cut about 2,400 metres before the work was stopped.

Today, many boring machines dig at rates of more than 120 metres in 24 hours. Some of the largest machines can cut round tunnels 11 metres in diameter.

In the late 1980's, excavation started on the Channel Tunnel, a tunnel to provide a rail link between the United Kingdom and France. Digging began at both ends and the boring machines met midway in December 1990. The tunnel opened in 1994.

The world's longest undersea transportation tunnel is the Seikan Tunnel, in Japan. It runs under the Tsugaru Strait between the islands of Honshu and Hokkaido, a distance of 53.9 kilometres. The tunnel began operation in 1988.

Related articles in *World Book* include:

Apennine Tunnel
Channel Tunnel
Fréjus Tunnels
Saint Gotthard Tunnels
Simplon Pass and Tunnel
Underground railway

Tunnel vision. See Eye (Diseases of the Retina).

Tunney, Gene (1897-1978), an American boxer, defeated Jack Dempsey in 1926 to become world heavyweight champion. Tunney defended his title twice—against Dempsey in 1927 and Tom Heeney in 1928—and then retired. The second Tunney-Dempsey bout featured a controversial "long count." Dempsey knocked Tunney down in the seventh round, but refused to go immediately to a neutral corner. The referee delayed starting the count over Tunney for about five seconds. Tunney rose at the count of nine and went on to win the fight. See **Dempsey, Jack.**

Tunney was born in New York City. Tunney began his professional boxing career in 1915. He enlisted in the U.S. Marine Corps in 1918 and won the American Expeditionary Forces light heavyweight title in Paris in 1919.

He defeated Battling Levinsky for the U.S. light heavyweight title in 1922. Tunney lost his title to Harry Greb later in 1922, but won again in 1923.

Tunny. See Tuna.

Tupac Amaru. See **Indian, American** (After European contact); **Peru** (Spanish conquest and rule).

Tupelo

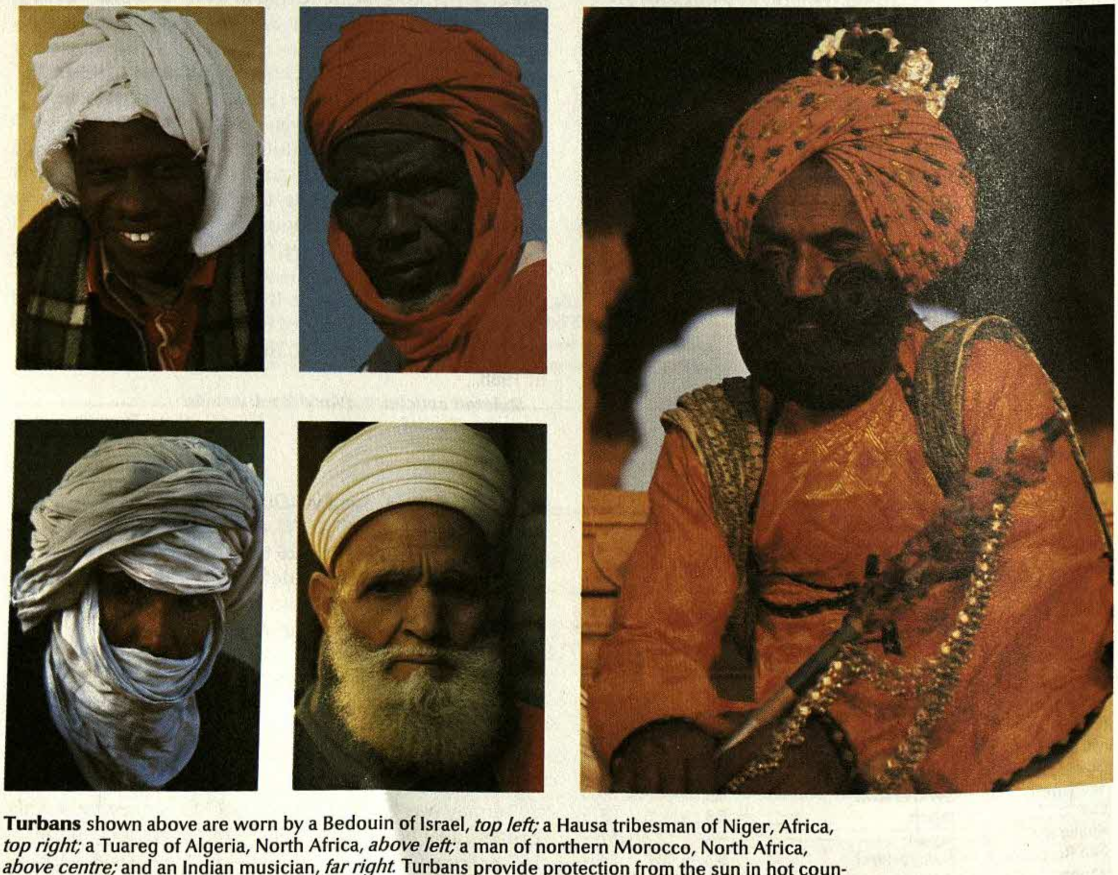
Tupelo is the name of several species of attractive trees native to North America, China, and Southeast Asia. The *water tupelo* grows in swamps in the Southeastern United States. It has large leaves and grows up to about 35 metres high. The trunk is swollen at the base. The tree bears greenish-white flowers and dark purple, berrylike fruit. The *black tupelo* grows in swamps and on moist land in the eastern, southern, and Midwestern United States. It is also called the black gum tree because of its dark grey bark. The black tupelo grows up to about 25 metres high. The leaves turn orange to scarlet in the autumn. The black tupelo is popularly planted as a shade tree.

The wood of North American tupelos is light coloured and is used to make baskets, panelling, pulp, shipping boxes, tool handles, and wooden ware. A Malaysian species of tupelo, known locally as *Hiroong,* has grey-brown wood that is used in the construction of houses, and for boards.

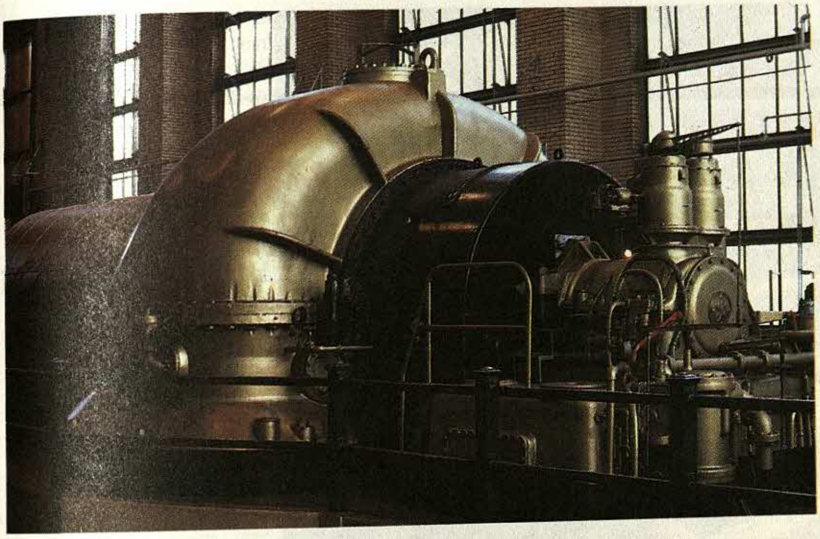
Scientific classification. Tupelos belong to the family Nyssaceae. The water tupelo is *Nyssa aquatica,* and the black tupelo is *N. sylvatica.* The Malaysan Hiroong is *N. javanica.*

Turaco. See Touraco.

Turban is a headdress. The name comes from the Persian word *dulband,* which means a scarf wound around the head. The first turbans were scarfs which men in the hot countries of the Asia and Middle East wrapped around their heads to provide protection against the sun. Gradually, turbans came to show differences in rank among the men of Asian countries. A white muslin scarf wound around a small cap on the head was the headdress of the priests of India, and native princes of that country wore showy silk scarfs. At one time, the sultan of Turkey wore a turban that was decorated with three heron feathers and many precious stones. The country's grand *vizier* (high official) wore two heron feathers in his turban, and a turban with one heron feather marked less important officers of Turkey's government. Men of the Sikh religion wear turbans in which they wind their hair.



Turbans shown above are worn by a Bedouin of Israel, *top left;* a Hausa tribesman of Niger, Africa, *top right;* a Tuareg of Algeria, North Africa, *above left;* a man of northern Morocco, North Africa, *above centre;* and an Indian musician, *far right.* Turbans provide protection from the sun in hot countries of Asia and Africa. Turbans may also indicate social rank.



An electric generator at a power plant, *left,* is driven by a steam turbine. High-pressure steam rushes past wheels in the turbine, causing them to spin rapidly. An axle transmits the mechanical energy of the rotating wheels to the generator. The steam turbine that powers this generator produces 119 million watts of power.

Turbine is a device with a rotor that is turned by a moving fluid, such as water, steam, gas, or the wind. A turbine changes the *kinetic energy* (energy of movement) of a fluid into a specific form of kinetic energy—energy of rotation. Such energy can be used to run machinery. Mechanical energy is transmitted by a turbine to other machinery through the spinning motion of the rotor's axle.

Turbines provide power for a variety of machines, including electric generators and water pumps. In fact, generators driven by turbines produce most of the electricity used to light homes and run factories. Turbines that power water pumps play an important role in irrigation projects throughout the world. Turbines are also used to turn the propellers of ships, and they are an essential part of jet-aeroplane engines.

The earliest known turbines date back to simple water wheels used by the ancient Greeks about 2,000 years ago. Today, turbines vary greatly in size and power, depending on their use. For example, a huge turbine that turns an electric generator can deliver nearly 750 million watts of power. But some turbines used to run shop machinery measure less than 2.5 centimetres in diameter and deliver under 750 watts.

How turbines work

The rotor is the rotating part of a turbine. In a simple turbine, it consists of a disc or wheel mounted on an axle. The axle sits either horizontally or vertically. The wheel has curved blades or buckets around the edges. Nozzles or movable gates called *guide vanes* aim the fluid at the blades or buckets and adjust its speed. In many turbines, a *casing* encloses the rotor. The casing holds the fluid against the rotor so that none of the fluid's energy is lost.

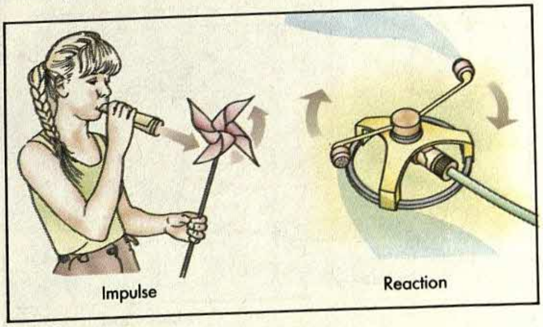
As a fluid passes through a turbine, it hits or pushes against the blades or buckets and causes the wheel to turn. When the wheel rotates, the axle turns with it. The axle is connected directly or through a series of gears to an electric generator, air compressor, or other machine. Thus, the circular motion of the spinning rotor drives a machine.

The rotors of some turbines have only one wheel. However, the rotors of others have as many as 50 or more. Multiple wheels increase the efficiency of turbines, because each wheel extracts additional energy from the moving fluid. In a turbine with more than one wheel, the wheels are mounted on a common axle, one behind the other. A stationary ring of curved blades is attached to the inside of the casing in front of each wheel. These stationary blades direct the flow of the fluid toward the wheels. A wheel and a set of stationary blades is called a *stage. Multistage* turbines are those that have many stages.

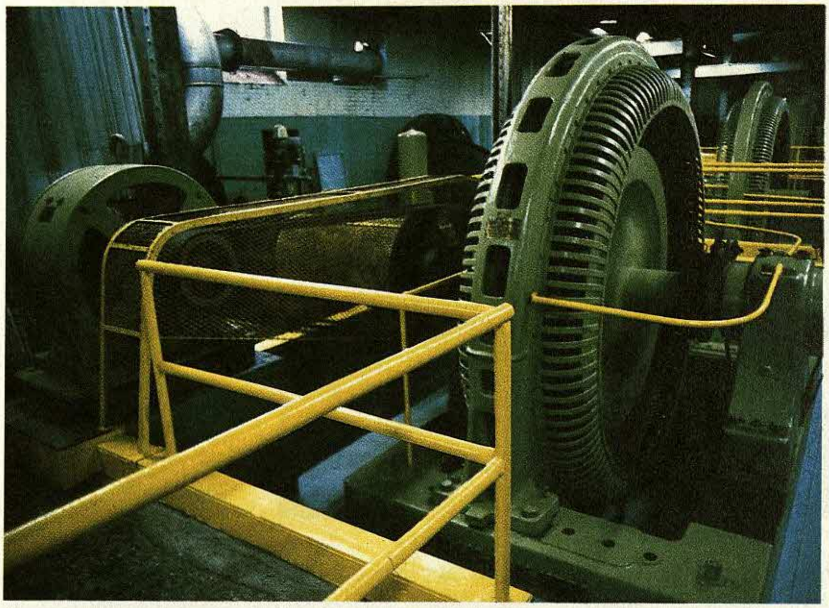
Kinds of turbines

Turbines are sometimes classified according to their principle of operation. All turbines operate by *impulse* or *reaction,* or by a combination of these principles. In an impulse turbine, the force of a fast-moving fluid striking the blades makes the rotor spin. In a reaction turbine, the rotor turns primarily as a result of the weight or pressure of a fluid on the blades.

Principles of turbine operation



Turbine wheels turn by *impulse* or *reaction.* A toy windmill, *left,* is a simple impulse turbine that rotates when air blows against the blades. A garden sprinkler, *right,* is a simple reaction turbine. Water squirting out of it under pressure causes the wheel to rotate.

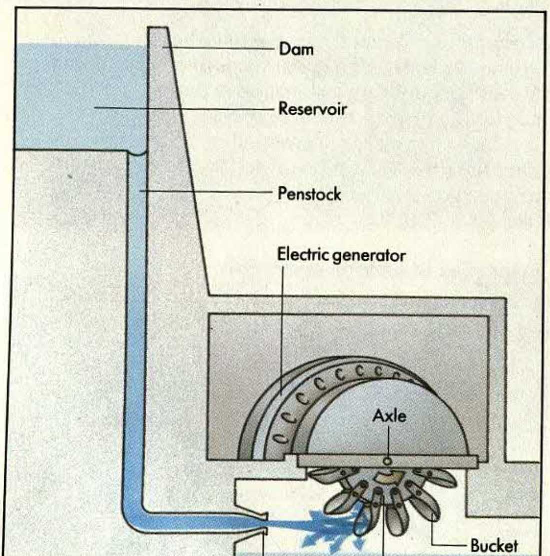


A water turbine is driven by water that "falls" from a great height through a pipe or other channel. The Pelton wheel turbine shown on the right in this photograph drives an electric generator in a paper mill.

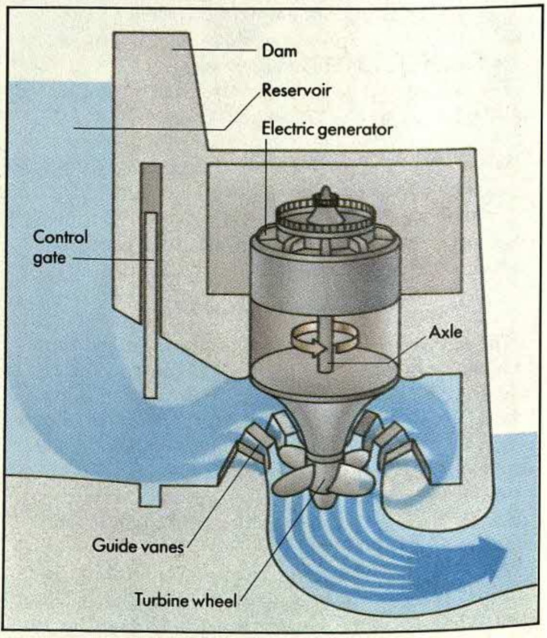
Turbines are more commonly classified by the type of fluid that turns them. According to this method, there are four main kinds of turbines: (1) water turbines, (2) steam turbines, (3) gas turbines, and (4) wind turbines.

Water turbines are also called *hydraulic turbines.* Most water turbines are driven by water from waterfalls or by water that is stored behind dams. The turbines are used primarily to power electric generators at hydroelectric power plants. There are three main kinds of water turbines: (1) the Pelton wheel, (2) the Francis turbine, and (3) the Kaplan turbine. The type of water turbine used at a plant depends on the *head* available. A head is the distance the water falls before it strikes the turbine. Heads range from about 2.5 metres to more than 300 metres.

The Pelton wheel is an impulse turbine. It is used with heads of more than 300 metres. A Pelton's rotor consists of a single wheel mounted on a horizontal axle.



The Pelton wheel, *above,* is an impulse water turbine. The force of water striking the turbine wheel causes it to spin. Water falls toward the turbine through a pipe called the *penstock* and hits the buckets on the wheel in a high-speed jet.



The Kaplan turbine is a reaction water turbine. The turbine wheel, which is completely underwater, is turned by the pressure of water against its blades. Guide vanes and a control gate regulate the amount of water reaching the wheel.

The wheel has cup-shaped buckets around its perimeter. Water from a lake or reservoir drops toward the turbine through a long pipe called a *penstock.* One to six nozzles at the end of the penstock increase the water's velocity and aim the water toward the buckets. The force of these high-speed jets of water against the buckets turns the wheel.

The Francis turbine is used when the head is between about 30 metres and 300 metres. A Francis turbine's rotor is enclosed in a casing. Its wheel has as many as 24 curved blades. Its axle is vertical. The wheel of a Francis turbine operates underwater. It is encircled by a ring of guide vanes, which can be opened or closed to control the amount of water flowing past the wheel. The spaces between the vanes act as nozzles to direct the water toward the centre of the wheel. The rotor is turned chiefly by the weight or pressure of the flowing water.

The Kaplan turbine is used for heads of less than 30 metres. The Kaplan rotor resembles a ship's propeller. It has from three to eight blades on a vertical axle. It works in a manner similar to that of a Francis turbine. Both the Kaplan turbine and the Francis turbine are reaction turbines.

Steam turbines drive the electric generators in most power plants. They also power ocean liners and large machinery. Multistage steam turbines are among the world's most powerful engines. Some steam turbines produce nearly 750 million watts of power.

Steam turbines are run by steam. In most cases, the steam is produced by water heated in a boiler by burning such fuels as coal, oil, or natural gas. In nuclear power plants, however, heat produced by splitting atoms in a nuclear reactor changes water to steam.

Steam enters a turbine at temperatures as high as 650° C and pressures as high as 250 kilograms per square centimetre. The high-pressure steam rushes through the turbine, causing the turbine wheels to spin rapidly. Steam turbines are designed to use the impulse principle, the reaction principle, or a combination of both.

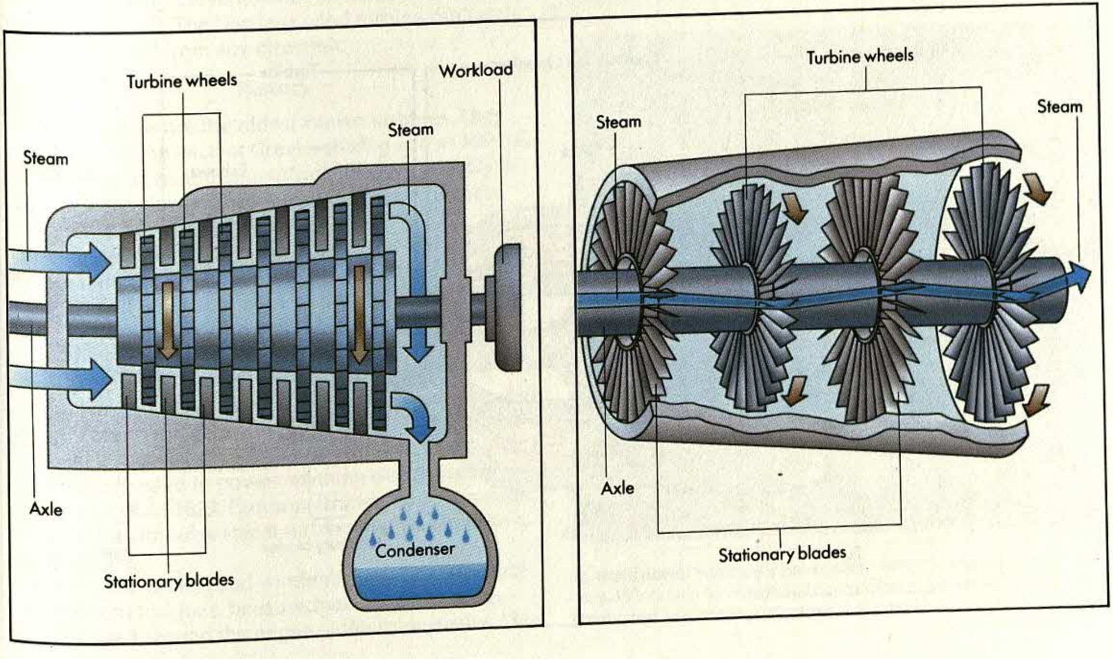
Many modern steam turbines have 50 or more stages set on a horizontal axle. Each stage of the turbine consists of a wheel and a ring of stationary blades. The curved blades of both the wheels and the stationary rings are shaped so that the spaces between them act as nozzles. The nozzles aim the steam and increase its speed before it goes on to the next stage. The steam follows a zigzag path between the wheel blades of one stage and the stationary blades of the next.

As steam passes through a multistage turbine, it expands to as much as 1,000 times its original volume. Each successive stage of the turbine is therefore larger than the previous one in order to make efficient use of the expanding steam. This arrangement gives steam turbines their characteristic conical shape.

Steam turbines may be either *condensing* or *noncondensing,* depending on how the steam leaving the turbine is used. Steam from a condensing turbine goes directly into a condenser. Cold water circulating in pipes in the condenser cools the steam into water. A vacuum is thus created, because the volume of water is much less than that of steam. The vacuum helps force steam through the turbine. The water is pumped back to the boiler to be made into steam again. The exhaust steam from noncondensing turbines is not cooled into water. Instead, it is used to provide heat for buildings and for a variety of industrial processes.

How a steam turbine works

Steam rushes through a steam turbine, turning a series of bladed wheels on a common axle. After the steam leaves the turbine, a condenser changes it into water, *left.* The cutaway view of a steam turbine, *right,* shows how a ring of stationary blades is positioned between each rotating wheel. Both the stationary blades and wheel blades aim the steam and increase its speed.



Gas turbines burn such fuels as oil and natural gas. Instead of using the heat to produce steam, as in steam turbines, gas turbines use the hot gases directly. Gas turbines are used to power electric generators, ships, and high-speed cars. They are also an important part of the engines in jet aircraft.

Most gas turbine systems have three main parts: (1) an air compressor, (2) a combustion chamber, and (3) a turbine. The combination of the air compressor and combustion chamber is commonly called a *gas generator.* In most gas turbine systems, the air compressor and turbine are mounted at either end of a common horizontal axle, with the combustion chamber between them. Part of the turbine's power runs the air compressor.

The air compressor sucks in air and compresses it, thereby increasing its pressure. In the combustion chamber, the compressed air combines with fuel and the resulting mixture is burned. The greater the pressure of the air, the better the fuel-air mixture burns. The burning gases expand rapidly and rush into the turbine, where they cause the turbine wheels to rotate. Hot gases move through a multistage gas turbine in much the same way that steam moves through a steam turbine. Stationary blades aim the moving gas at the rotor blades and adjust its velocity.

Most gas turbine systems make use of the hot exhaust gases from the turbine. In some systems, some of the exhaust gases are circulated to a device called a *regenerator.* There, the gases are used to warm up the high-pressure air from the compressor before it enters the combustion chamber. Such preheating of the air reduces the amount of fuel needed for combustion. In jet engines, much of the gas stream is used to develop thrust (see **Jet propulsion**).

Gas turbines run at even higher temperatures than steam turbines. The higher the temperature at which a gas turbine runs, the more efficiently it operates. The temperature in many gas turbines is 875° C or higher.

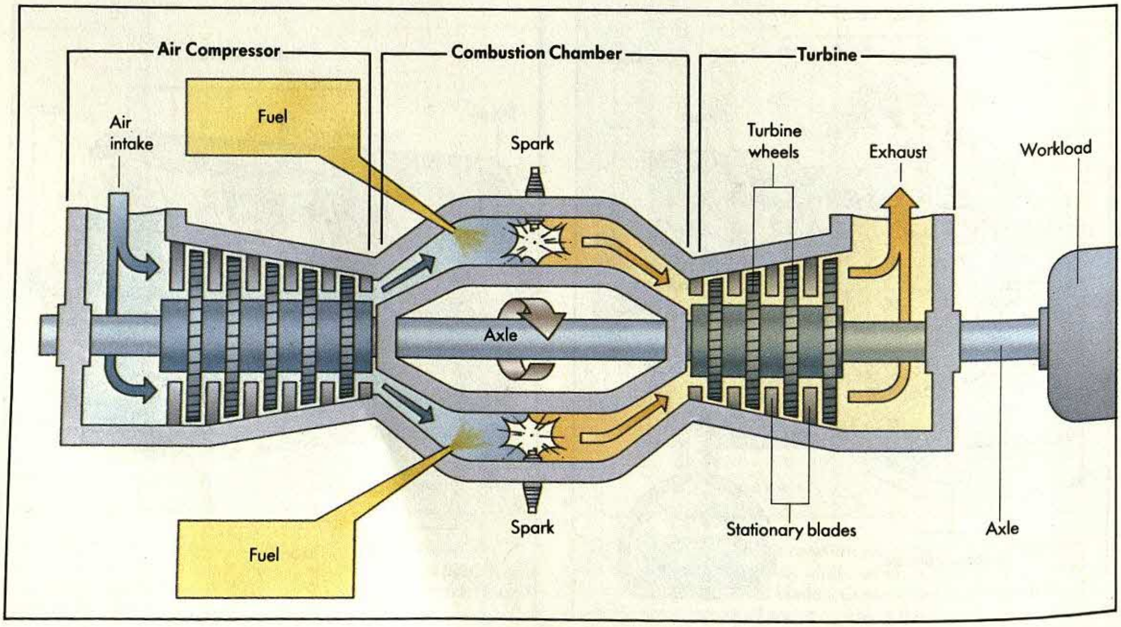
Wind turbines, commonly called *windmills,* are driven by the wind. They were developed about 1,300 years ago, and over the centuries have been used chiefly to grind grain and pump water. By the late 1700's, windmills were in use in many countries throughout the world. In the 1800's, they began to be replaced in some countries by more efficient, enclosed turbines. During the 1970's, shortages of oil led to increased interest in wind turbines for generating electricity.

There are two basic types of wind turbines: (1) horizontal axis wind turbines (HAWT's) and (2) vertical axis wind turbines (VAWT's).

Horizontal axis wind turbines. Traditional HAWT's have rotors with multiple blades or sails. They include *Dutch windmills* and *American windmills* (see **Windmill**). Most modern HAWT's that are used to generate electricity have two propellerlike blades. The rotor of these HAWT's is mounted on a tower or mast that holds the blades high enough off the ground to catch the wind stream. In order for the turbine to operate efficiently, the blades need to face into the wind, and the axle must lie parallel to the wind stream. As the wind blows, the rotor turns due to the impact of the air on the specially shaped blades. HAWT's are designed to adjust to changes in the speed and direction of the wind. The angle of the blades can be changed to keep the turbine operating at a constant rate, no matter what the wind speed is. In addition, these turbines can be rotated around a vertical axis to keep the rotor blades facing into the wind.

How a gas turbine system works

In a gas turbine system, compressed air is forced into a combustion chamber and mixed with fuel. A spark ignites the mixture and hot gases rush through the turbine, spinning the wheels. Wheel blades and stationary blades direct the gases through the turbine and increase their speed. Part of the turbine's power is used to run the air compressor.



The Darrieus wind turbine is a vertical axis wind turbine. Darrieus wind turbines are extremely efficient because they can catch the flow of wind from any direction.

Vertical axis wind turbines. The most efficient kind of vertical axis wind turbine was developed in the 1920's by a French inventor named Georges Darrieus. The Darrieus wind turbine looks like a giant eggbeater. It has two or three long curved blades attached at both ends to a vertical shaft. The Darrieus wind turbine can catch the flow of wind from any direction.

History

Water wheels are the oldest known turbines. They were used by the ancient Greeks as long ago as 100 B.C. for grinding grain and squeezing oil from olives. By the A.D. 300's, the Romans had introduced water wheels into many other parts of Europe.

The first windmills were probably built in the A.D. 600's in Iran. These early windmills were used for grinding grain and irrigating crops. By the 1100's, they had spread to Europe. In the 1400's, people in the Netherlands began using windmills to drain marshes and lakes near the sea.

For many centuries, water wheels and windmills were the only useful turbines. The scientist Hero of Alexandria had built a small steam turbine by about A.D. 60, but it had not been used to power anything (see **Steam engine** [History]). In 1629, Giovanni Branca, an Italian engineer, built an impulse steam turbine that was used in a stamping mill.

Early water wheels and windmills were less efficient than modern turbines, because much of the moving fluid escaped around the edges of the rotor blades. During the 1800's, engineers and inventors began developing more efficient, enclosed turbines. In 1824, Claude Burdin, a French engineer, introduced the word *turbine* in a scientific paper. It comes from the term *turbo,* the Latin word for a spinning object. Benoît Fourneyron, a French engineer, built the first successful enclosed water turbine in 1827. After Fourneyron's success, engineers soon overcame most of the problems that were involved in building efficient water turbines.

In 1849, an English-born inventor named James B. Francis built the first Francis turbine. The Pelton wheel, which had been invented by an American mining engineer named Lester A. Pelton, began to be produced during the 1880's. Victor Kaplan, an Austrian inventor, developed the design for the Kaplan turbine during the early 1900's.

In 1884, an English inventor, Charles A. Parsons, developed the first reaction steam turbine. In 1897, he used steam turbines to power his vessel, the *Turbinia.* In 1895, Charles G. Curtis, an American inventor, patented a multistage steam turbine that worked by both reaction and impulse. This turbine marks the beginning of a revolution in power production, because it was extremely efficient for its size and weight. During the early 1900's, steam turbines replaced steam engines in electrical generating stations.

John Barber, an English inventor, was issued a patent on a simple gas turbine system in 1791. In 1930, an English engineer named Frank Whittle received the first patent on the application of a gas turbine to propel aircraft. The first aeroplane to be powered by a turbojet engine was built by the Heinkel Company of Germany in 1939.

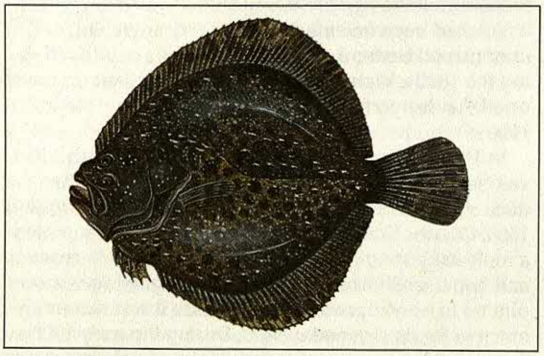
Related articles in ***World Book*** include:

Dam
Electric power
Energy
Free-piston engine
Hydraulic engine
Hydraulics
Jet propulsion
Locomotive
Ship (Increasing power and speed)
Steam engine
Water power
Water wheel
Windmill

A traditional windmill has blades radiating from a horizontal axis. Windmills have provided mechanical power for pumping water and performing other work for about 1,300 years.

Turbofan. See **Jet propulsion** (Turbofan).
Turbojet. See **Jet propulsion** (Turbojet).
Turboprop. See **Jet propulsion** (Turboprop); **Turbine** (Gas turbines).

Turbot is a large flatfish that lives along the Atlantic Coast of Europe and in the Mediterranean Sea. From the side it looks almost as round as a plate. It seldom grows over 60 centimetres long and usually weighs from about 8 to 14 kilograms. But fishing crews sometimes catch 25-kilogram turbot that measure more than 75 centimetres long. The turbot is flat and wide, with a long fin on its top and bottom ridges. Hard, round knobs cover its brown upper side. Both eyes are on the left side. The turbot lays as many as 10 million eggs, which float on the surface of the sea. The young fish that hatch settle to the bottom and live there.



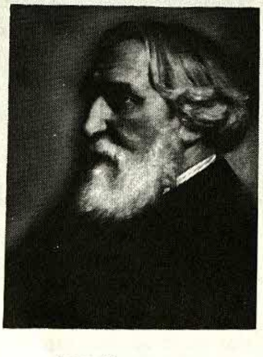
The flat-bodied turbot of Europe's North Atlantic coastal waters has eyes only on one side of its body. When it swims, the eyeless side is on the underside.

Turbot are valuable commercially. Turbot became a favourite fish of the English. The *American spotted turbot* and the *hornyhead turbot* also are flatfishes but belong to a different family.

Scientific classification. The European turbot belongs to the family Bothidae. It is *Scophthalmus maximus.*

See also **Flatfish; Flounder.**

Turgenev, Ivan (1818-1883), was one of the greatest Russian novelists. He was the first Russian writer to achieve substantial recognition in the West. Turgenev became noted for his realistic portrayals of the Russian nobility and intellectuals. He examined social and cultural interests in novels that read like a diary of that part of Russian society from the 1840's to the 1870's. These novels are *Rudin* (1856), *A Nest of Gentlefolk* (1859), *On the Eve* (1860), *Fathers and Sons* (1862), *Smoke* (1867), and *Virgin Soil* (1877).



Ivan Turgenev

In his novels and in the short story "The Diary of a Superfluous Man" (1850), Turgenev described a type of educated, well-meaning, but disillusioned Russian nobleman. This type of character, known as the "superfluous man," is unable to find an outlet for his talents and energies. This passive and politically ineffective figure was the most common type of male character in Russian literature of Turgenev's time. In contrast, the female characters in Turgenev's novels are more resourceful and strong-willed.

Turgenev's masterpiece, *Fathers and Sons,* is about the young Russian radicals of the 1860's. Bazarov, the main character of the book, is a *nihilist*—that is, a person who opposes all tradition and authority (see **Nihilism**). Bazarov is a powerful and convincing character, but he dies inactive and frustrated.

Ivan Sergeyevich Turgenev was born and grew up on his family's estate in Orel, Russia. He first won recognition as a writer in 1852 with his *A Sportsman's Sketches.* This collection contains sympathetic portrayals of the Russian peasants. Turgenev's best-known drama is *A Month in the Country* (1850). Turgenev spent several decades in the West, and he was part of a group who believed Russia's future depended on its adoption of the best elements of Western culture.

Turin (pop. 1,103,520) is a city in northern Italy that lies on the Po River. Its Italian name is Torino. Turin is the capital of Piedmont, one of Italy's 20 political regions. For location, see **Italy** (political map).

Turin is one of the loveliest places in northern Italy. Beautiful parks and botanical gardens stretch along the left bank of the Po. The great church of the Superga stands on a hill near the city. A cable railway runs to the top of the hill. From the hill, travellers enjoy a fine view of Turin. Many beautiful *piazzas* (public squares) provide open space in the city. The Shroud of Turin is kept in a chapel of the Turin cathedral. Many people believe the shroud to be the cloth in which the body of Jesus Christ was wrapped in his tomb (see **Shroud of Turin**).

Turin is an old city, with a long and interesting history. In 218 B.C., the Carthaginian general, Hannibal, crossed the Alps and captured the city. In A.D. 69, a great fire swept Turin and many buildings burned to the ground. From 1861 to 1865, Turin served as the first capital of the Kingdom of Italy. The royal palace and park are still famous landmarks.

Educational institutions include several military schools, an observatory, museums, and a science academy. The University of Turin was founded in 1404. The city has a library that houses a collection of ancient writings.

During World War II (1939-1945), Turin served as an important munitions-manufacturing centre for Italy and Germany. Many of the city's factories were destroyed by Allied air raids in 1942 and 1943. But the city recovered from the destruction of the war. Today, Turin has become one of Italy's leading industrial centres. Its chief products include fine silk materials and various kinds of Italian cars.

Turing, Alan Mathison (1912-1954), an English mathematician, made important contributions to the development of electronic digital computers. In 1937, he described a hypothetical computing machine, now called the *Turing machine,* that could, in principle, perform any calculation. The device had a long tape divided into squares on which symbols could be written or read. The tape head of the machine could move to the left or to the right. The machine also had a table to tell it the order in which to carry out operations. The Turing machine became an important tool for determining what could be programmed on a computer.

Turing was born in London. He studied mathematics at Cambridge University, England, and at Princeton University, U.S.A. During World War II (1939-1945), he helped crack German codes. After the war, he worked on a project to build the first British electronic digital computer. In 1950, he proposed a test for determining if machines might be said to "think." This test, now called the *Turing test,* is often mentioned in discussions of *artificial intelligence* (see **Artificial intelligence**).

Turing machine. See **Turing, Alan Mathison.**

Turk. See **Turks.**

Turkestan, also spelled *Turkistan,* a vast geographical region in Asia, has no definite boundaries. Turkestan stretches from Siberia in the north to Iran, Pakistan, India, and Tibet in the south. The Mongolian Desert lies to the east, and the Caspian Sea to the west. The name *Turkestan* refers to the Turkic-speaking tribes that have lived in this region since as early as the A.D. 500's.

For hundreds of years, Turkestan has linked Europe with eastern Asia. Many ancient trade routes crossed the area, including Marco Polo's Golden Road. During World War II (1939-1945), Turkestan provided a route for transporting arms from the Soviet Union to China.

Western Turkestan, formerly also called Soviet Turkestan, lies between the Caspian Sea and the Tian Shan range. Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan make up Western Turkestan. Flat and sandy in the north and west, the land rises to form mountains in the southeast. Rivers from the mountains flow inward, to disappear in the desert sands. Most of the people are Muslims and make their living by farming and raising cattle. Irrigation ditches provide water for wheat, rice, millet, oats, and cotton. Chief cities include Tashkent, Almaty, Qaraghandy, Bishkek, Dushanbe, and Samarqand.

Chinese Turkestan, also called Eastern Turkestan, in the heart of Asia, extends east from Western Turkestan to the Gobi Desert and Tibet. The Tian Shan range in the north, and the Kunlun Mountains, rising over 6,000 metres in the south, border the region. Chinese Turkestan, which forms part of China's Xinjiang region, has a harsh, dry climate. The people are of Turkish origin and are called *Uigurs.* They make their living by farming, raising domestic animals, and trading. Most of them are Muslims. Major cities include Urumqi, Hami, Karamay, Kashi, and Yining.

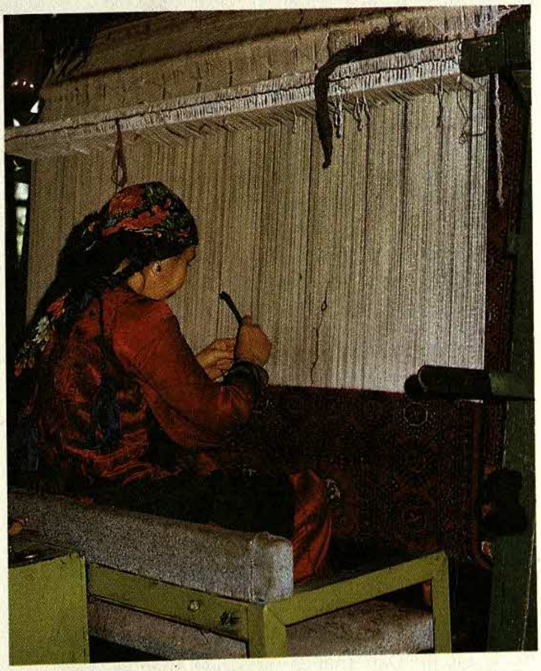
Afghan Turkestan is bounded on the north by the Amu Darya (Oxus River), and on the northwest by Western Turkestan. Uzbek chiefs ruled the country for a long time before Afghanistan gained possession of it. This part of southern Turkestan forms the Afghan province of Mazar-i-Sharif. Afghan Turkestan's many mountains have rich copper, iron, lead, and gold deposits. The people of this region are chiefly of Persian and Uzbek stock.

History. The known history of Turkestan began about the time of Christ, when much of it belonged to the Chinese Empire. In the 500's, Turkic-speaking tribes conquered the rich trading cities of Bukhara and Samarqand. In the 600's, Tibet gained control of Eastern Turkestan, but later the Chinese again took the region. In the 900's, the Muslim religion began to spread over Eastern Turkestan. Turkic-speaking nomads from central Asia invaded Turkestan in 1073. Followers of Genghis Khan swept through the land in the 1200's. Bukhara and Samarqand in Western Turkestan became centres of Muslim culture during the 1300's and 1400's.

The Muslims in Eastern Turkestan made repeated attempts to set up their own government, especially in the 1800's. Chinese Turkestan almost became an independent state from 1872 to 1876, under the kingship of Yakub Beg. But after he died, China regained control. Chinese Turkestan is now governed as a part of the province of Xinjiang.

Russia began to extend its rule to Western Turkestan after the Russian conquest of Siberia during the 1600's. During the 1700's, Kazakh tribes accepted Russian authority. Most of Western Turkestan became Russian during the 1800's. The Russian czar's government created the province of Turkestan and made Tashkent the capital of the province. In 1887, an Anglo-Russian commission established the boundary between Afghanistan and Russian Turkestan.

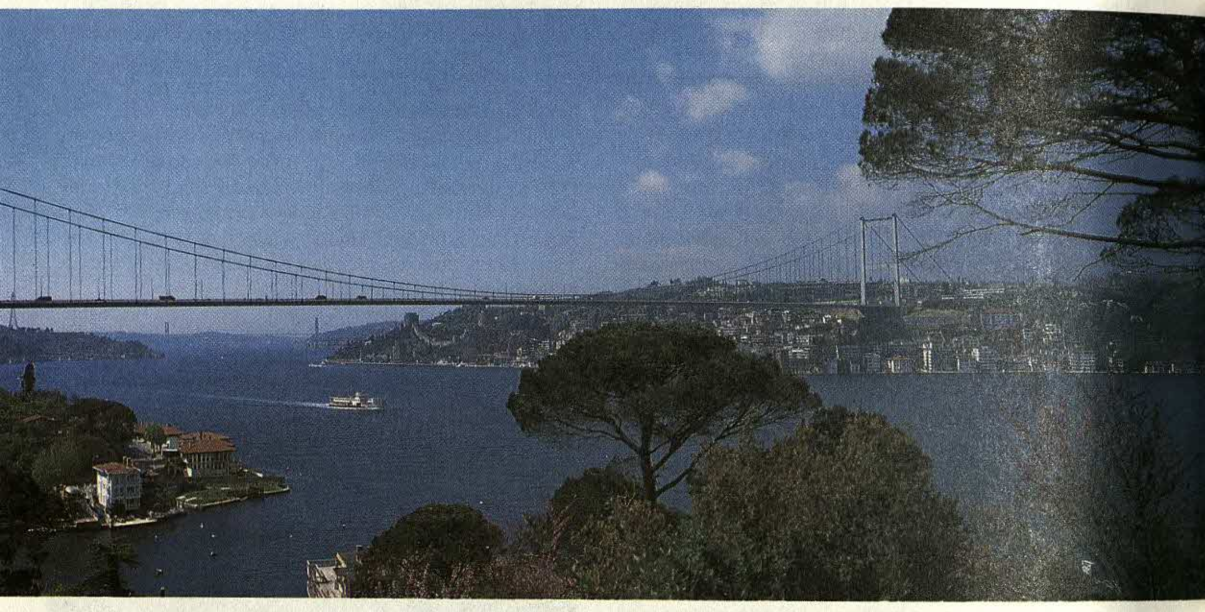
In the 1920's and 1930's, Western Turkestan was divided into five separate states of the Soviet Union: the Kazakh, Kyrgyz, Tajik, Turkmen, and Uzbek Soviet Socialist Republics. The Soviet government developed the region's resources. It also built schools, extended irrigation systems, and laid additional railway lines. In 1991, following the collapse of the Soviet Union, each of the five republics became independent.



A Western Turkestan woman weaves a rug on a loom. Turkestan rug weavers are world famous for their skill.

Related articles in ***World Book*** include:

Aral Sea
Genghis Khan
Kazakhstan
Kyrgyzstan
Tajikistan
Tashkent
Turkmenistan
Uzbekistan
Xinjiang



The "New" Bosporus Bridge, opened in 1988, eases the flow of Istanbul's traffic. One of the longest suspension bridges in the world, it is the second link between the Asian and European parts of the city.

Turkey

Turkey is a Middle Eastern nation that lies both in Europe and in Asia. About 3 per cent of the country occupies the easternmost tip of southern Europe, a region called *Thrace.* Istanbul, Turkey's largest city, lies in this region of green, fertile hills and valleys. To the east, the rest of Turkey covers a large, mountainous peninsula called *Anatolia* or *Asia Minor.* Anatolia has several large cities, including the capital city of Ankara, and areas of rich farmland. But much of Anatolia is rocky, barren land.

Turkey borders Bulgaria on the northwest; Greece on the west; Georgia, Armenia, Azerbaijan, and Iran on the east; and Iraq and Syria on the south. The Black Sea lies to the north, the Aegean Sea to the west, and the Mediterranean Sea to the south.

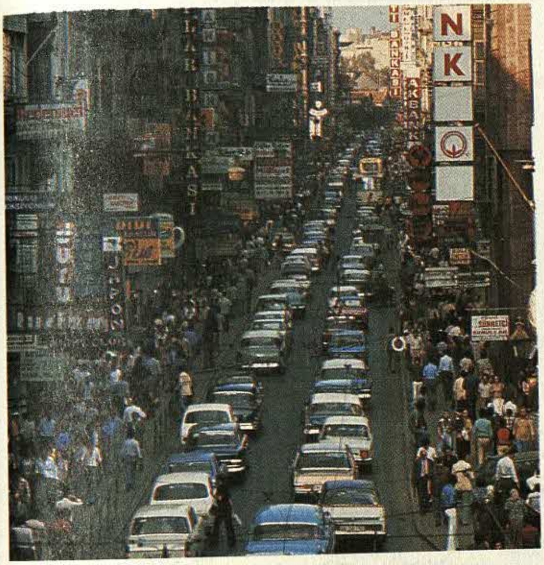
Three bodies of water—the Bosporus, the Sea of Marmara, and the Dardanelles—separate Anatolia from Thrace. These waters, often called the *Straits,* have had a major role in Turkish history. By its control of the Straits, Turkey can regulate the movement of ships between the Mediterranean Sea and the Black Sea.

About 60 per cent of Turkey's people live in cities or towns. The rest live on farms or in small villages. Nearly all the people are *Muslims* (followers of Islam). Turkey is a developing country, and more than half of its workers are farmers. However, Turkey's economy has become increasingly industrialized since the mid-1940's. As a result, manufacturing now contributes more to the national income than does agriculture.

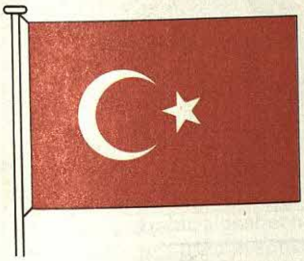
Various Asian and European peoples have ruled what is now Turkey since ancient times. During the A.D. 1300's, a group of Muslim Turks called the *Ottomans* began to build a powerful empire that eventually controlled much of the Middle East, southeastern Europe, and northern Africa. After the abolition of the Ottoman Empire in 1922, the Republic of Turkey was created the following year.

Facts in brief about Turkey

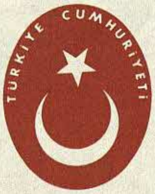
Capital: Ankara.
Official language: Turkish.
Official name: Türkiye Cumhuriyeti (Republic of Turkey).
Head of state: President.
Political divisions: 75 provinces.
Area: 779,452 km². *Greatest distances*— north-south, 748 km; east-west, 1,633 km. *Coastline*—3,558 km.
Elevation: *Highest*—Mount Ararat, 5,185 m. *Lowest*— sea level along the coast.
Population: *Estimated 1996 population*—63,204,000; density, 77 people per km²; distribution, 40 per cent rural, 60 per cent urban. *1990 census*—56,473,035. *Estimated 2001 population*—69,262,000.
Chief products: *Agriculture*—barley, maize, cotton, fruit, potatoes, sugar beet, wheat. *Manufacturing*—fertilizers, iron and steel, machinery, motor vehicles, processed foods and beverages, pulp and paper products, textiles and clothing.
National anthem: "Istiklâl Marşi" ("Independence March").
National emblem: Crescent and star.
National motto: *Yurtta sulh, Cihanda sulh* (Peace at home, peace in the world).
National holiday: National Day, October 29.
Money: *Currency unit*—Turkish lira. One lira = 100 kurus.



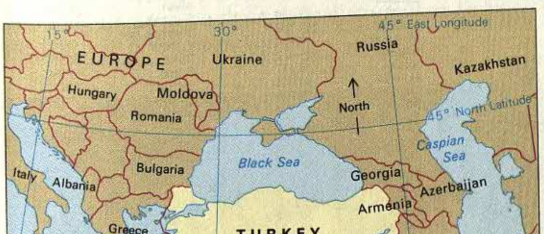
Endless lines of traffic jam both Istanbul's modern boulevards and its ancient streets. The city is Turkey's centre of commerce and industry.



Turkey's flag was adopted in 1936. The crescent and five-pointed star are traditional symbols of the Islamic faith.



The coat of arms, adopted in 1923, bears the nation's official name, Republic of Turkey, in Turkish.



Turkey is a country in the Middle East. It covers the peninsula of Asia Minor and a small section of southeastern Europe.

Islamic law had strongly influenced Turkish life for nearly 1,000 years. However, Turkey's new republican government introduced sweeping cultural and political reforms that discouraged or outlawed many traditional Islamic practices. Most of the Turkish people accepted the reforms. However, many others, especially those living in rural areas, resisted the changes. This conflict over the role of Islam in Turkish life continues to reflect different beliefs and opinions.

Government

Turkey is a republic. Its Constitution was adopted in 1982, following two years of military rule. It provides for a parliamentary form of government that includes a president, a prime minister and cabinet, and a legislature called the Grand National Assembly. The president, prime minister, and cabinet took office in 1982. The Grand National Assembly was first elected by the Turkish people in 1983. Further general elections were held in 1987 and 1991.

The president is Turkey's head of state, commander in chief of the armed forces, and the presiding officer at cabinet meetings. The Grand National Assembly elects the president to a seven-year term.

The prime minister and cabinet. The prime minister is Turkey's head of government. The president selects the prime minister from among the most influential members of the legislature. The members of the cabinet, called the Council of Ministers, are nominated by the prime minister and appointed by the president. Cabinet ministers supervise the various government departments. The prime minister must submit a proposed government programme and the names of cabinet ministers to the legislature for a *vote of confidence.* The prime minister and cabinet ministers must resign if the legislature refuses to grant a vote of confidence in their policies.

The Grand National Assembly was given the power by the Constitution to make Turkey's laws, ratify treaties, and declare war.

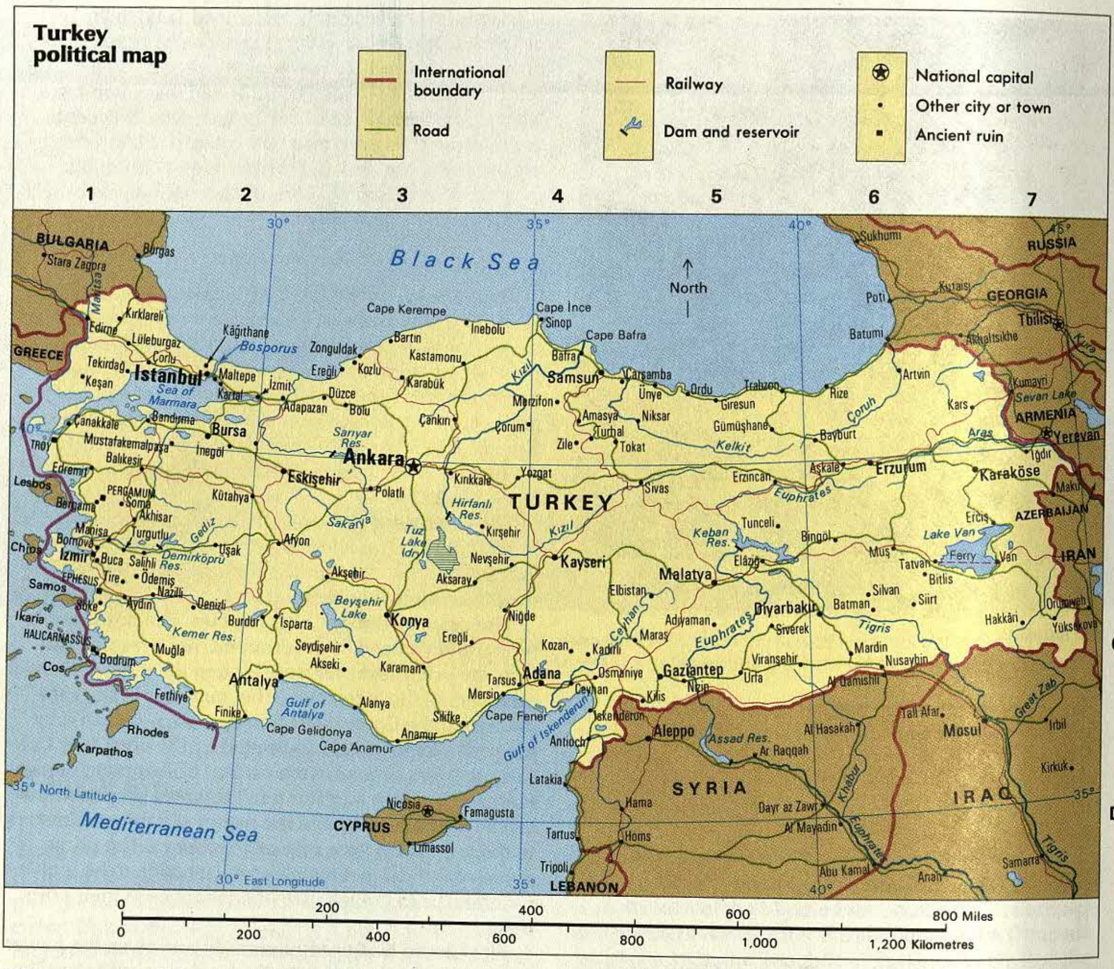
The Assembly consists of 450 deputies elected by the voters to five-year terms. If the president disapproves of any bill passed by the legislature, the bill is returned to the legislature. If the legislature then repasses the bill, it becomes law.

Court system. Courts throughout Turkey handle commercial disputes, criminal trials, and other cases. The Court of Cassation reviews the decisions of lower courts. The Constitutional Court determines the legality of laws passed by the legislature.

Local government. Turkey is divided into 75 provinces. Each has a governor appointed by the president and a council elected by the people. Provinces are divided into counties, districts, *municipalities* (communities of 2,000 or more people), and villages.

Political parties. A coalition government has been formed by the True Path Party, which favours free enterprise, and the Social Democratic Populist Party, which favours a mixture of free enterprise and government controls. There are nine other political parties represented in the Assembly.

Armed forces. About 650,000 men serve in Turkey's army, navy, and air force. Men from 20 to 32 years old may be conscripted for 18 months of service.



Turkey political map

Cities, towns, and villages

City	Population	Key	
Adana	777,554	C	4
Adapazari	152,291	B	2
Adiyaman	71,644	C	5
Adrianople, see Edirne			
Afşin*	26,805	C	5
Afyon	87,033	B	2
Ağri*	54,492	B	7
Akhisar	68,553	B	1
Aksaray	81,056	C	3
Akşehir	45,320	C	3
Alanya	28,733	C	3
Alaşehir*	29,484	C	2
Alexandretta, see Iskenderun			
Amasya	53,431	B	4
Anamur	28,726	D	3
Ankara	2,235,035	B	3
Antakya, see Antioch			
Antalya	261,114	C	2
Antioch (Antakya)	107,821	D	4
Artvin	18,720	A	6
Aşkale	14,472	B	6
Aydin	90,449	C	1
Bafra	53,482	A	4
Balikesir	149,989	B	1
Bandirma	70,137	B	1
Bartin	25,117	A	3
Batman	110,036	C	6
Bayburt	28,068	B	6
Bergama	38,849	B	1
Bingöl	34,024	B	6
Birecik*	25,998	C	5
Bismil*	24,862	C	6
Bitlis	36,073	C	6
Bolu	50,288	B	3
Bolvadin*	35,509	B	2
Bozüyük*	25,130	B	2
Buca	103,105	C	1
Burdur	53,995	C	2
Bursa	612,510	B	2
Çanakkale	48,059	B	1
Çankiri	41,420	B	3
Çarsamba	34,189	A	4
Çeyhan	72,624	C	4
Çeylanpinar*	25,781	C	6
Cizre*	29,496	C	6
Çorlu	59,107	A	1
Çorum	96,725	B	4
Çumra*	24,175	C	3
Darica*	33,551	B	2
Denizli	169,130	C	2
Develi*	25,944	C	4
Dinar*	28,598	C	2
Diyarbakir	305,940	C	6
Doğubeyazit*	31,134	B	7
Dörtyol*	30,722	C	4
Düzce	45,077	B	3
Edirne (Adrianople)	86,909	A	1
Edremit	30,159	B	1
Elâzig	182,296	C	5
Elbistan	48,756	C	5
Erbaa*	28,840	B	4
Erciş	36,582	B	7
Erdemli*	26,074	C	4
Ereğli	54,837	A	3
Ereğli	68,749	C	3
Ergani*	33,209	C	5
Erzincan	82,616	B	5
Erzurum	246,053	B	6
Eskişehir	366,765	B	2
Fatsa*	29,811	B	5
Fethiye	21,442	C	2
Gaziantep	478,635	C	5
Gebze*	92,592	B	2
Gemlik*	36,693	B	2
Giresun	55,887	B	5
Gölcük*	56,087	B	2
Gümüshane	22,067	B	5
Hakkâri	20,754	C	7
Iğdir	29,460	B	7
Ilgin*	22,539	C	3
Inegöl	54,659	B	2
Iskenderun (Alexandretta)	152,096	C	4
Islahiye*	29,031	C	4
Isparta	101,215	C	2
Istanbul	5,475,982	A	2
Izmir (Smyrna)	1,489,772	C	1
Izmit (Kocaeli)	233,338	B	2
Kadirli	47,609	C	4
Kâğithane	175,540	A	2
Kâhta*	25,510	C	5
Karabük	94,818	A	3
Karacabey*	25,384	B	2
Karaköse	314,350	B	7
Karaman	64,735	C	3
Karapinar*	26,231	C	3
Kars	69,293	B	7
Kastamonu	46,986	A	3
Kayseri	373,320	C	4
Keşan	34,518	A	1
Kilimli*	34,748	A	3
Kilis	59,876	C	5
Kirikhan*	52,780	C	4
Kirikkale	208,018	B	3
Kirklareli	40,881	A	1
Kirşehir	64,754	B	4
Kiziltepe*	40,852	C	6
Kocaeli, see Izmit			
Konya	439,181	C	3
Kozan	50,324	C	4
Kozlu	35,691	A	3
Kütahya	118,773	B	2
Lüleburgaz	43,420	A	1
Malatya	243,138	C	5
Maltepe	90,439	A	2
Manisa	127,012	B	1
Maraş	210,371	C	5
Mardin	44,085	C	6
Menemen*	24,998	B	1
Mersin	216,308	C	4
Merzifon	37,027	B	4
Milas*	23,622	C	1
Muğla	31,279	C	1
Muş	42,159	B	6
Mustafakemalpaşa	33,904	B	2
Nazilli	77,627	C	1
Nevşehir	50,204	C	4
Niğde	49,068	C	4
Niksar	28,348	B	5
Nizip	50,067	C	5
Nusaybin	45,178	C	6
Ödemiş	47,475	C	1
Ordu	80,828	B	5
Osmaniye	103,824	C	4
Patnos*	25,046	B	7
Pazarcik*	23,382	C	5
Polatli	52,737	B	3
Reyhanli*	37,471	D	4
Rize	50,221	A	6
Salihli	63,759	C	1
Samandaği*	27,477	D	4
Samsun	240,674	A	4
Sarikamiş*	23,583	B	6
Seydişehir	37,226	C	3
Siirt	53,884	C	6
Silifke	28,111	C	3
Silvan	45,825	C	6
Sincan*	50,869	B	5
Sinop	23,148	A	4
Sivas	198,553	B	5
Siverek	48,333	C	5
Smyrna, see Izmir			
Söke	44,556	C	1
Soma	39,088	B	1
Sorgun*	24,777	B	4
Suluova*	32,717	B	4
Sungurlu*	28,780	B	4
Sürüc*	25,660	C	5
Tarsus	146,502	C	4
Tatvan	51,906	C	6
Tavsanli*	30,506	B	2
Tekirdağ	63,215	A	1
Tire	35,044	C	1
Tokat	73,008	B	4
Trabzon	142,008	B	5
Tunceli	18,471	B	5
Turgutlu	65,740	B	1
Turhal	60,097	B	4
Ünye	35,508	B	5
Urta	194,969	C	5
Uşak	88,267	B	2
Uzunköprü*	33,878	A	1
Van	110,653	C	7
Viranşehir	45,329	C	6
Yakacik*	29,374	C	4
Yalova*	53,857	B	2
Yarimca*	48,420	B	2
Yerköy*	26,062	B	4
Yozgat	43,686	B	4
Zile	37,097	B	4
Zonguldak	117,879	A	3

*Does not appear on map; key shows general location.

Source: 1985 census.

People

Population and ancestry. For Turkey's total population, see the *Facts in brief* table at the start of this article. About 85 per cent of the people are descendants of an Asian people called *Turks.* Turks began to migrate to Anatolia from central Asia during the A.D. 900's. Kurds form Turkey's largest minority group, making up about 10 per cent of the population. Most live in mountainous regions of the southeast.

Turkey also has several smaller minority groups. Arabs, most of whom are farmers, live near the Syrian border. Caucasians—people whose ancestors came from the Caucasus Mountains region which lies just northeast of Turkey—live in the provinces bordering the Black Sea. Greeks and Armenians live in the Istanbul area.

About 60 per cent of Turkey's people live in cities and towns, and about 40 per cent live in rural areas. The number of urban dwellers has increased rapidly since the 1940's. Hundreds of thousands of people have left their farms and villages to seek work in the cities. But the cities do not have enough jobs for all the people. As a result, many Turks have gone abroad to work. Many Turkish citizens work in other parts of the Middle East and in Australia, Canada, and several countries of western Europe.

Languages. More than 90 per cent of all Turks speak Turkish, the country's official language. About 6 per cent speak Kurdish. The rest speak Arabic, Greek, or one of the other languages of the minority groups.

The government began to develop the modern Turkish language during the late 1920's. For hundreds of years, the written language was Ottoman Turkish, a complicated language written in Arabic characters. However, the Arabic alphabet had no letters to represent many sounds used in spoken Turkish. In addition, Ottoman Turkish included words and grammar from the Arabic and Persian languages. Ottoman Turkish was so difficult that only scholars and the ruling class learned to read it. In 1928, the government established a new alphabet and eliminated most foreign words from the language. The government also ordered a language education programme throughout the country and discouraged the use of Ottoman Turkish.

A crowded street along the Istanbul waterfront reflects the rapid growth of Turkish cities since the 1940's. More than half of Turkey's people live in cities and towns.

Ways of life have changed greatly in Turkey since the 1920's, when a new republican government was established. The government set out to make Turkey a modern state and so began a programme to sweep away the customs and traditions of centuries.

Since the 1920's, one of the government's major goals has been to change the status of women in Turkish life. Men have dominated Turkish society for hundreds of years. Before the 1920's, women had almost no civil rights. Parents arranged the marriages of their daughters by means of a contract with the groom's family. The bride had little voice in the matter. In addition, women could not vote and had difficulty getting a divorce. During the 1920's, the government outlawed the arrangement of marriages by contract and made it easier for women to get a divorce. The government also gave women the right to vote and to receive maintenance. Today, increased educational opportunities and exposure to Western ideas are gradually improving the position of Turkish women.

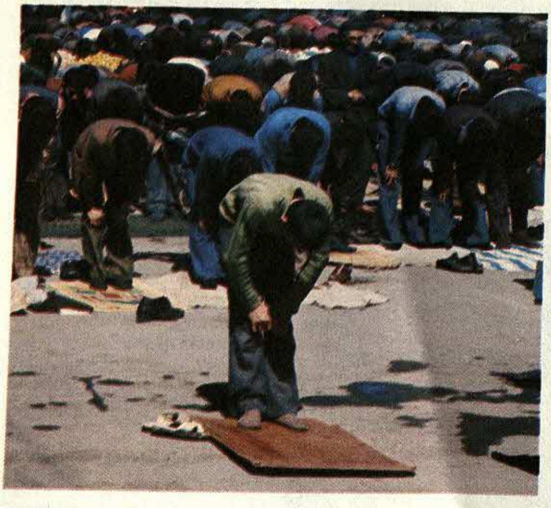
The Kurds of Turkey make up the nation's largest minority group. Most of them live in the mountainous regions of the southeastern part of the country. They herd sheep and goats and grow such crops as cotton, tobacco, and sugar beet.

The government also tried to bring the Kurds and other tribal people into the mainstream of modern Turkish life. Many Turks, as well as the Kurds, lived in tribal groups as nomads or in isolated communities for centuries. During the 1920's, the government began to force these people to abandon their tribal way of life as a means of modernizing Turkish society. The Kurds revolted against these attempts several times in the 1920's and 1930's. Since then, some Kurds adopted modern Turkish culture while serving in the armed forces or attending school outside areas with large Kurdish populations. Today, almost all nomads have settled in villages in rural areas. They farm, or raise livestock.

Housing varies throughout Turkey. Turks who live near the Black Sea build thatch-roofed cottages with timber from nearby forests. In rural areas of Thrace and northeastern Anatolia, many people have replaced their old wooden homes with one-storey houses of concrete blocks. Many villagers in central Anatolia live in flat-roofed houses of sun-dried brick. Stone houses are common in southern and western Anatolia.

Most wealthy Turks live in luxurious concrete-block houses on the outskirts of cities or in suburban apartment complexes. Middle-class city dwellers live in old two- and three-storey wooden houses or in concrete homes. The rapid growth of industry in the major cities has created a severe housing shortage among workers who moved to the cities from rural areas. As a result of the housing shortage, large shantytowns have sprung up at the edges of Turkish cities.

Clothing worn by the people of Turkey changed dramatically during the 1920's. The government discouraged or forbade the wearing of certain garments required by Islamic custom. City dwellers and many rural people then adopted Western clothing styles. However, some Turks in rural areas still cling to Islamic tradition. Only a few men wear the traditional loose-fitting cloak and baggy trousers. But rural women still continue some of the old clothing customs. These women wear a simple blouse and pantaloons. They cover their head and often the lower part of the face with a scarf as a sign of modesty.



Islamic rituals, such as group prayer, *above,* play an important part in the daily life of most Turks. About 98 per cent of the people of Turkey are Muslims.

Education in Turkey has made rapid progress. But the nation still does not have enough schools or teachers. Many children, unlike these youngsters, do not receive a primary education.

Food and drink. Cracked-wheat bread and yogurt are the chief foods of most Turks. Turks also eat much lamb, rice, and aubergine. Turkish cooks are especially famous for their tasty *shish kebab,* which consists of pieces of lamb, tomatoes, peppers, and onions cooked together on a skewer. They also combine rice with almonds, meat, pine nuts, and raisins in a dish called *pilaf.* For snacks, Turks enjoy *borek,* a flaky pastry stuffed with meat or cheese. A popular dessert is *baklava,* made of thin layers of pastry, honey, and chopped nuts. Another pastry, *kadayif,* is made with shredded wheat. Favourite beverages of the Turks include tea, thick coffee flavoured with sugar, and a liquor called *raki,* which is made from raisins.

Recreation. Family outings and celebrations are the most common forms of recreation in Turkey. The people also enjoy drinking coffee or tea at a restaurant with a scenic view. Many men spend their leisure time in coffee houses playing the ancient dice game of backgammon. Archery, horse riding, soccer, and wrestling are popular sports. A Turkish form of wrestling called *greased wrestling* is a favourite event at festivals and wrestling matches. Contestants wear tight leather trousers and cover their bodies with olive oil to make the holds more difficult. The Turkish people also enjoy concerts, films, stage plays, and operas.

Religion. More than 98 per cent of the Turkish people are Muslims. However, Turkey has no state religion, and the Constitution guarantees religious freedom. The population thus includes members of the Armenian Apostolic and Greek Orthodox churches, Roman and Eastern Catholics, and Jews.

One of the most controversial issues in Turkey is whether Turkish society should be organized on a worldly or religious basis. Islamic law provides specific rules for all activities of life—economic, political, and social. In the 1920's, the government made religion a private matter, restricting it to personal morals and behaviour. But many Turks strongly objected. Today, the dispute continues over what part Islam should have in Turkish life.

Education. About 69 per cent of Turkey's people 15 years old and older can read and write. The government's greatest challenge in education is in rural areas. The government spends about 10 per cent of its budget on public education, and much of this money is used for the education of rural people. But rising costs and a lack of qualified teachers prevent the nation from providing enough schools in rural areas.

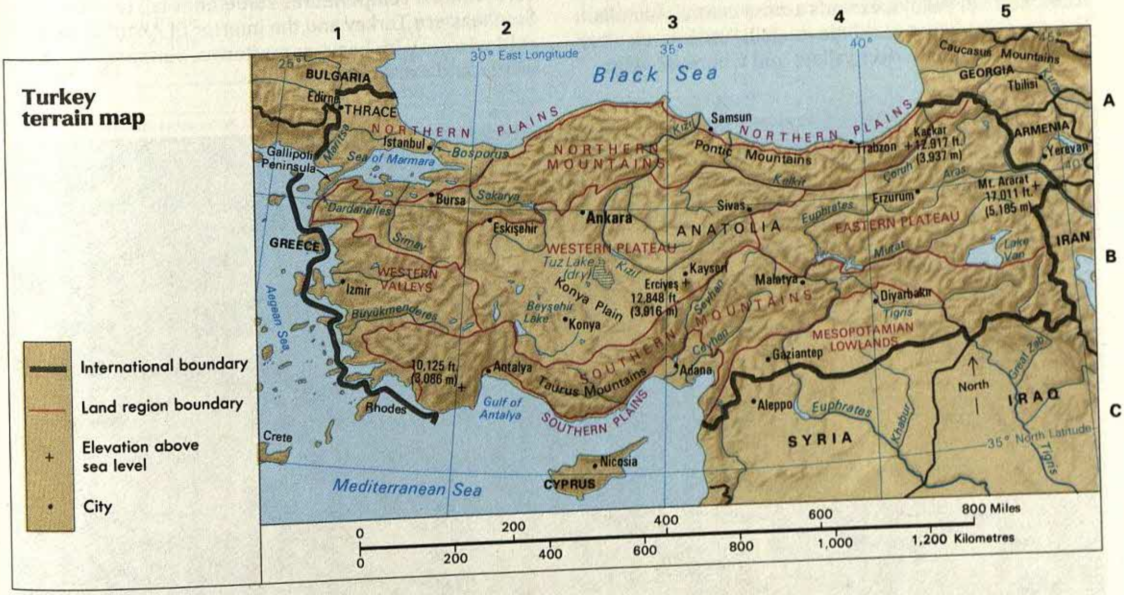
Turkish law requires all children to attend a five-year primary school until they graduate or reach the age of 15. However, this law is difficult to enforce. After graduation, students may attend a middle school for three years. Some middle-school graduates enter a three-year pre-university secondary school called a *lise.* Other middle-school graduates enrol in a technical college or enter the work force. Many lise graduates go on to university. Turkey has about 25 universities. Istanbul University, the oldest and largest university in Turkey, was founded in 1453. The university has more than 30,000 students.

The arts. Turkey's most important contribution to the arts is in the field of architecture. In Istanbul stands the great-domed cathedral Hagia Sophia, a classic example of Byzantine architecture. It was built in the A.D. 500's, when Turkey was part of the Byzantine Empire. Turkish *mosques* (Islamic houses of worship) were built throughout Anatolia during the 1200's. These structures, with their thin *minarets* (towers), follow the Persian and Arabic style of architecture. Many of Turkey's finest buildings were constructed during the 1400's and the 1500's, when the Ottoman Empire was at its height. A large number were designed by Koca Sinan, who is considered Turkey's greatest architect. His majestic Mosque of Suleiman I in Istanbul is one of the world's most beautiful mosques.

For hundreds of years, Turkish craftworkers have made excellent dishes, bowls, and other objects of ceramics. The best-known ceramics centre in Turkey is at Kütahya, in Anatolia. Richly coloured ceramic tiles decorate many mosques and palaces. The art of making these decorative tiles was developed early in Turkey. The tiles were used in *mosaics* (wall decorations made of tiny pieces of glass, tile, and gold put together). When the Ottoman Turks conquered Constantinople in 1453, they plastered over the mosaics in the cathedral Hagia Sophia. The cathedral was converted into a mosque. The mosaics were gradually restored after the building became a museum in 1933.

Turkish weavers have long been famous for their elaborately designed rugs. They made many of the first Oriental rugs used in Europe. Turkey also produces fine shawls and towels.

Most of Turkey's traditional literature is written in the complicated Ottoman Turkish language and deals with religious themes and life during Ottoman rule. Modern Turkish literature centres largely on nationalism, social justice, and folk history. In some works, modern writers include stories from ancient folk dramas about the legendary puppet character Karagöz (Black Eyes). In these folk dramas, the clever Karagöz produces much laughter as he outwits his enemies.


Turkey terrain map

Physical features

Aegean Sea	B	1
Anatolia (region)	B	3
Ararat (mountain)	B	5
Aras River	A	5
Beyşehir Lake	B	2
Black Sea	A	3
Bosporus (strait)	A	2
Büyükmenderes River	B	1
Ceyhan River	B	3
Çoruh River	A	4
Dardanelles (strait)	A	1
Erciyeş (mountain)	B	3
Euphrates River	B	4
Gallipoli Peninsula	A	1
Gulf of Antalya	C	2
Kaçkar (mountain)	A	4
Kelkit River	A	4
Kizil River	A	3
Konya Plain	B	2
Lake Van	B	5
Maritsa River	A	1
Murat River	B	4
Pontic Mountains	A	3
Sakarya River	A	2
Sea of Marmara	A	1
Seyhan River	B	3
Simav River	B	1
Taurus Mountains	C	2
Thrace (region)	A	1
Tigris River	B	4
Tuz Lake	B	2

Land

Turkey covers 779,452 square kilometres in the northwestern part of the Middle East. Much of Thrace and the coastal areas of Anatolia consist of lowlands and green, rolling plains. A broad expanse of dry highlands called the *Anatolian Plateau* stretches across central Anatolia. The plateau is bordered by the Pontic Mountains in the north and the Taurus Mountains in the south.

Turkey has several large saltwater lakes and numerous rivers. But most of the rivers dry up during the country's hot, dry summers. In the spring, many rivers become torrents as waters from the melting snows rush down from the mountains, overflow the riverbanks, and flood the surrounding countryside.

Turkey can be divided into eight land regions. They are (1) the Northern Plains, (2) the Western Valleys, (3) the Southern Plains, (4) the Western Plateau, (5) the Eastern Plateau, (6) the Northern Mountains, (7) the Southern Mountains, and (8) the Mesopotamian Lowlands.

The Northern Plains cover Thrace and extend along the Black Sea coast of Anatolia. Thrace's gently rolling grasslands make it an important farming and grazing region. Along the Black Sea coast, farmers raise fruit, maize, nuts, and tobacco.

The Western Valleys are broad, fertile river valleys along the Aegean Sea coast. The region produces barley, maize, olives, tobacco, and wheat. The value of its crop output exceeds that of any other region.

The Southern Plains are a narrow strip of land along the Mediterranean Sea. A great variety of crops, including cereal grain, citrus fruit, cotton, and olives, grow in the region's rich soil. Farmers must irrigate their fields during the hot, dry summer.

The Western Plateau, a region of highlands and scattered river valleys, extends across central Anatolia. The region receives very little rainfall. Farmers raise barley and wheat in the river valleys and wherever irrigation water is available. Goats, sheep, and other livestock graze on uncultivated land.

The Eastern Plateau is a rugged area of towering mountains and barren plains. It extends from the Western Plateau to Turkey's eastern border. The Taurus and Pontic mountains meet in this region. Mount Ararat, the country's highest point, rises 5,185 metres above sea level, near the Iranian border. Most of the region's people have small farms.

The Northern Mountains, or Pontic Mountains, rise between the Northern Plains and the Anatolian Plateau. Only a few roads and railways connect the plateau with the Black Sea.

The Southern Mountains consist of the Taurus Mountains and several smaller ranges on the southern edge of the Anatolian Plateau. These mountains almost completely cut off the plateau from the Mediterranean Sea.

The Mesopotamian Lowlands are fertile plains and river valleys in southeastern Anatolia. Cereal grain and fruit grow well in the region's rich soil.

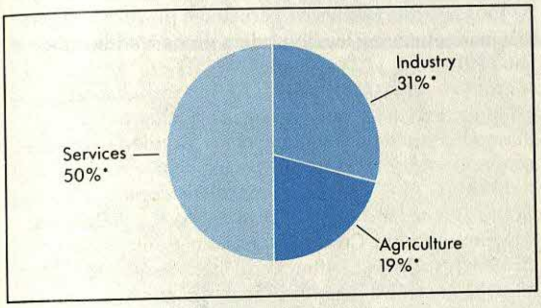
Climate

The climate differs greatly from one region of Turkey to another. Thrace and the south and west coasts of Anatolia have mild, rainy winters and hot, dry summers. Summer temperatures along the Aegean often rise above 32° C. The Black Sea coast has cooler summers, with an average temperature of about 22° C. Yearly rainfall in coastal areas averages from about 50 to 75 centimetres along the Aegean and Mediterranean to more than 250 centimetres in the regions that border the Black Sea.

Northeastern Turkey has mild summers but bitterly cold winters. Temperatures sometimes fall to −40° C. Southeastern Turkey and the interior of Anatolia have cold winters with heavy snowstorms. Summers are hot, windy, and extremely dry.

Vast barren plains cover much of central Anatolia. The region receives little or no rain during the hot summer, so few crops can be grown without extensive irrigation. Many of the region's people, like this herdsman, raise sheep or other livestock.

Turkey's gross national product



The gross national product (GNP) is the total value of goods and services produced by a country in a year. The GNP measures a nation's total economic performance and can also be used to compare the economic output and growth of countries. Turkey's GNP was 108,630,000,000 U.S. dollars in 1991.

Workers by economic activities

Economic activities	Number of workers†	Per cent of total
Agriculture, forestry & fishing	9,355,649	43
Community, social & personal services	2,971,173	13
Construction	1,026,582	4
Financing, insurance, property & business services	437,953	2
Manufacturing	3,030,423	14
Mining & quarrying	234,350	1
Transportation, storage & communication	904,963	4
Utilities	15,134	‡
Wholesale/retail trade, restaurants & hotels	2,351,324	11
Unemployed	*1,571,721*	7
Total:	21,899,272	100

*Based on gross domestic product (GDP). GDP is the total value of goods and services produced within a country in a year.

†Figures are for 1990.

‡Less than 1 per cent.

Sources: International Labour Organization; OECD; World Bank; The Economist Intelligence Unit.

Economy

Turkey has a developing economy. When the republican government came to power in the 1920's, Turkey was almost entirely an agricultural country. Under the direction of the Turkish government, the number of factories increased from 118 in 1923 to more than 1,000 in 1941. Today, Turkey has over 30,000 factories. But agriculture remains an important economic activity. It provides jobs for about 58 per cent of the country's workers. However, farm output accounts for only about 20 per cent of the value of all goods and services produced in Turkey. Manufacturing employs only around 11 per cent of all workers, but the value of industrial production exceeds that of agricultural output.

The national government has long been heavily involved in many aspects of Turkey's economy. The government has owned much of the country's transportation and communication industries, and it has controlled other industries as well. However, private companies have become increasingly important. During the late 1980's, the government began a programme to reduce its ownership of industries and to allow more private control of companies.

Agriculture. Turkey's most productive farmlands are in the coastal regions, which have fertile soil and a mild climate. Farmers on the desertlike Anatolian Plateau raise wheat and barley. However, the plateau region often has long droughts that cause serious losses of crops.

In most years, Turkey's farmers produce enough food for all the people plus a surplus to sell abroad. About 50 per cent of the cropland is used for grain. Wheat is the chief grain, followed by barley and maize. Large amounts of cotton are grown for both fibre and cottonseed oil. Tobacco, a major Turkish export, is grown along the coasts of the Black and Aegean seas. Turkey is a major producer of fruit, nuts, and vegetables, including apples, aubergines, grapes and raisins, hazel nuts, melons, oranges, potatoes, sugar beet, and tomatoes. Turkey's farmers also raise sheep, goats, and other livestock. Wool is the country's most valuable livestock product.

Manufacturing. Turkey's largest manufacturing industries are the processing of food and beverages and the production of textiles. Other leading manufactured products include fertilizers, iron and steel, machinery and metal products, motor vehicles, and pulp and paper products. Most of Turkey's factories and mills are in and around the large cities in the northern and western parts of the country.

Mining. Turkey is rich in mineral resources, but the mining industry is largely undeveloped. The country's most abundant mineral is coking coal, which is used in steelmaking. Turkey is one of the world's largest producers of chromite, the mineral from which chromium is obtained. The nation also produces and refines petro-

Manufacturing is one of Turkey's chief industries. Most textile workers are employed in modern mills. Others, such as these women, work at home. The women are weaving an Oriental rug.

leum. Other minerals produced in Turkey include bauxite; boron; copper; iron ore; and *meerschaum,* a soft, white mineral that is used to make jewellery and tobacco pipes.

Foreign trade. The government's programme to boost Turkey's industry requires the nation to export as many products as possible and import large quantities of machinery and raw materials. The nation spends more money on these and other imports than it receives for its exports. As a result, Turkey has an *unfavourable balance of trade.* Turkey's chief imports include chemicals, machinery, iron and steel, motor vehicles, and petroleum. Major exports include clothing and textiles, chemicals, cotton, fruit, nuts, and tobacco. Turkey's main trading partner is Germany. Other leading partners include France, Iran, Iraq, Italy, the United Kingdom, and the United States.

Transportation and communication. Turkey's road network reaches almost all the nation's towns. But many roads are unpaved. Less than 2 per cent of the people own cars. Most Turks use buses, trains, or taxis. The railway system links the country's chief cities. Government-owned Turkish Airlines serves many cities in Turkey, Europe, and the Middle East. Istanbul and Ankara have international airports. Turkey has many natural harbours. Istanbul and Izmir are the country's primary ports.

Turkey has more than 1,000 daily newspapers, representing many different political views. Most Turkish families own a radio. Turkey has an average of about 1 television set for every 10 people.

History

Archaeologists have found evidence of an advanced society in what is now Turkey before 6000 B.C. The first inhabitants of the area to be recorded in history were a people called the Hittites. About 2000 B.C., they began to migrate to central Anatolia from Europe or central Asia. During the next several hundred years, they conquered much of Anatolia and parts of Mesopotamia and Syria. By 1500 B.C., the Hittites had created a powerful empire that made them the leading rulers of the Middle East. See **Hittites.**

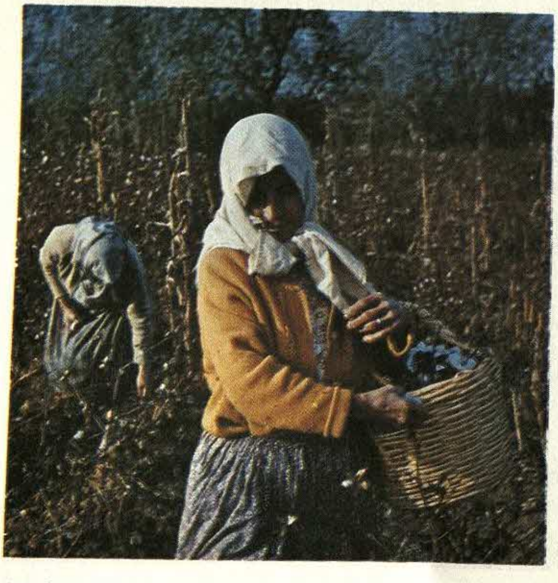
From about 1200 to 500 B.C., large areas of Anatolia fell to the Phrygians, the Lydians, and other peoples. During the same period, the Greeks founded many city-states along Anatolia's Aegean coast. Between about 550 and 513 B.C., the Persian Empire seized control of Anatolia and Thrace. The Persians held control until the general Alexander the Great, king of Macedonia, crushed their army in 331 B.C. After Alexander's death in 323 B.C., Anatolia became a battleground in the wars among his successors. Small kingdoms rose and fell until 63 B.C., when the Roman general Pompey the Great conquered the region. Anatolia was at peace under Roman rule for nearly 400 years.

In A.D. 330, the Roman emperor Constantine the Great, one of the last rulers of the united Roman Empire, moved the capital from Rome to the ancient town of Byzantium in Thrace. Byzantium was renamed *Constantinople,* meaning *city of Constantine.* In 395, the Roman Empire split into two parts—the East Roman Empire, which included Anatolia and Thrace, and the West Roman Empire. Barbarians conquered the West Roman Empire in the mid-400's. But the East Roman Empire, also called the Byzantine Empire, thrived. As a result, Byzantine emperors came to rule all of what is now Turkey until the late 1000's. See **Byzantine Empire; Constantine the Great.**

The Seljuk Turks became one of the first Turkish peoples to rule in Turkey. The Seljuks were Muslims from central Asia east of the Caspian Sea. During the mid-1000's, they conquered Armenia; the Holy Land, or Palestine; and most of Iran. Then they invaded Anatolia. In 1071, the Seljuks destroyed most of the Byzantine power in Anatolia by defeating the Byzantine army in the Battle of Manzikert. They set up an empire with Iconium (now Konya) as the capital. From this point onward, the Christian religion and the Greek language of the Byzantine Empire were gradually replaced in Anatolia by Islam and the Turkish language.

In 1095, Christians in western Europe organized the first of a series of military expeditions called the *Crusades* to drive the Turks from the Holy Land (see **Crusades**). During the First Crusade (1096-1099), Christian troops defeated the Seljuk Turks in western Anatolia. As a result, the Byzantine Empire recovered about a third of Anatolia. But the crusaders then left the peninsula to fight in the Holy Land. The Seljuk Empire thus endured until 1243, when it was invaded by Asian nomads known as Mongols (see **Mongol Empire**).

The rise of the Ottoman Empire. The Mongol Empire was torn by internal struggles and soon fell apart. As a result, the Turks' influence in Anatolia continued to grow. During the 1300's, a group of Turks called the Ottomans began to build a mighty empire. In 1326, they seized the Anatolian city of Bursa, which became their capital. By the late 1300's, the Ottomans had conquered the western two-thirds of Anatolia; most of Thrace; and much of the Balkan Peninsula, including Greece. All that remained of the Byzantine Empire was the area around Constantinople.



Hard-working Turkish farmers pick cotton in one of the country's cotton fields. Turkey is a world leader in cotton production, and cotton is one of the nation's most valuable exports.

The conquest of Constantinople by the Turks in 1453 ended the Byzantine Empire, which had ruled in Turkey since the 300's.

In 1453, Ottoman forces led by Muhammad II captured Constantinople, ending the Byzantine Empire. The Turks called the city Istanbul and made it their capital. By 1481, their empire extended from the Danube River in Europe to southern Anatolia.

The Ottoman Empire reached its height in the 1500's. During the reign of Sultan Bayezid II, who ruled from 1481 to 1512, the empire became the leading naval power in the Mediterranean region. Ottoman forces conquered Syria in 1516 and Egypt in 1517. Suleiman I, whom Europeans called the *Magnificent,* ruled from 1520 to 1566. In 1526, his army conquered much of Hungary in the Battle of Mohács. Suleiman also expanded the empire's borders to Yemen on the south, Morocco on the west, and Persia on the east.

The start of the Ottoman decline. After the Battle of Mohács, European powers feared that the Turks would overrun Europe. However, European forces successfully defended Vienna, Austria, during a Turkish attack in 1529. In 1571, European fleets defeated the Turkish navy in the Battle of Lepanto, near Greece. The Turks again failed to capture Vienna in 1683.

During the 1700's, the Ottoman Empire continued to weaken. In 1774, the Turks lost a six-year war against Russia and were forced to allow Russian ships to pass through the Straits—the Turkish waters that link the Black Sea with the Mediterranean. The Ottoman Empire lost the Crimea, a peninsula in the Black Sea, to Russia in 1783.

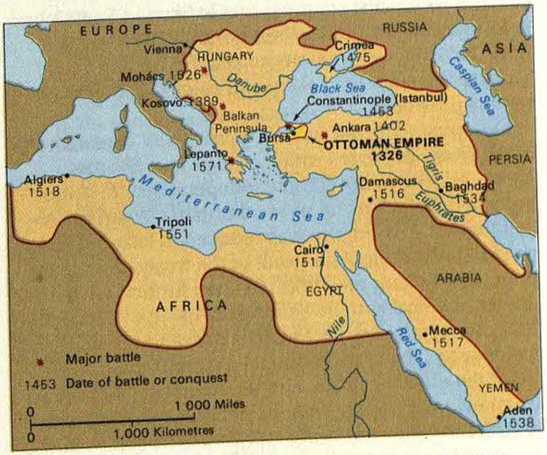
"The Sick Man of Europe," as the Ottoman Empire came to be called, lost more territory during the 1800's. In 1821, Greek nationalists revolted against Ottoman rule. France, Great Britain, and Russia sided with the Greeks and sent forces to fight the Turks (see **Greece** [History]). The Treaty of Adrianople (Edirne) ended the fighting in 1829. It acknowledged the independence of Greece and gave Russia control of the mouth of the Danube River. The Turks also lost other Balkan territory in a series of wars with Russia (see **Russo-Turkish wars**). But European powers forced Russia to give up much of its gains at the Congress of Berlin in 1878. The Ottoman Empire continued to decline, however. The Turks had lost Algeria to France in 1830, and France seized Tunisia in 1881. Great Britain gained Cyprus in 1878 and Egypt in 1882.

Ottoman leaders tried to halt the empire's decline through a reform programme. They reorganized the military and improved the educational system. In 1876, the empire's first constitution was adopted. It provided for representative government and granted the people various freedoms. However, Sultan Abdul-Hamid II, who came to the throne the same year, set the constitution aside and ruled as a dictator. Government policies became increasingly violent, and Abdul-Hamid ruled by the use of fear. Religious persecution began to spread as members of various religious minorities became revolutionaries. Nationalist feelings were strong among the minorities. Ottoman officials, fearing further collapse of the already declining empire, reacted harshly. Violent attacks took place. Between 1894 and 1918, the Christian Armenians in the Ottoman Empire suffered an especially large loss of life (see **Armenia** [History]).

The Young Turks. During the late 1890's, small groups of Turkish students and military officers who opposed Abdul-Hamid's harsh policies banded together secretly. The most influential group was the Young Turks. In 1908, the Young Turks led an army revolt against Abdul-Hamid and forced him to restore constitutional government. But the sultan soon staged an unsuccessful counterrevolution, and the Young Turks made him give up the throne in 1909. They then ruled the empire through his brother Muhammad V.

The Young Turks wanted to restore the greatness of the Ottoman Empire. However, many Turkish people no longer cared about the idea of maintaining an empire. In addition, the empire's Christian minorities demanded freedom from Ottoman rule. And so the empire continued to crumble. Soon after the revolution in 1908, Bulgaria declared its independence, and Austria seized Bosnia. Italy took Libya in 1912. In 1913, the Ottoman Empire surrendered Crete, part of Macedonia, southern Epirus, and many Aegean islands to Greece. By 1914, the empire had lost all its European territory except eastern Thrace.

In 1914, the Ottoman Empire entered World War I on



The Ottoman Empire began during the 1300's as a small state around the city of Bursa. It grew to include much of the Middle East and parts of northern Africa and southeastern Europe.

Important dates in Turkey

1500 B.C. The Hittites, the earliest known inhabitants of what is now Turkey, ruled in Anatolia.

63 B.C. The Roman general Pompey conquered Anatolia.

A.D. 330 Constantine the Great moved the capital of the Roman Empire to Byzantium and renamed the town Constantinople.

1071 The Seljuk Turks conquered most of Anatolia by defeating the Byzantine forces in the Battle of Manzikert.

1326 The Ottoman Turks captured Bursa, which marked the beginning of the Ottoman Empire.

1453 The Ottomans captured Constantinople, ending the Byzantine Empire.

1783-1914 The Ottoman Empire lost much of its territory in a series of military defeats.

1908 The Young Turks revolted against the government.

1914-1918 In World War I, the Ottoman Empire allied with Germany and lost much of its remaining territory.

1923 Mustafa Kemal (Atatürk) set up the Republic of Turkey and began a programme to modernize the nation.

1947 Turkey received economic and military aid from the United States to resist Soviet expansion.

1960 Turkish army units overthrew the government and ruled until free elections were held in 1961.

1974 Turkish forces invaded Cyprus.

1980 Army units again took control of the government.

1983 The government was returned to civilian control.

---

the side of Germany and Austria-Hungary in an attempt to regain lost territory. In 1915, British, French, and other Allied troops tried to gain control of the Straits so that aid could be shipped to Russia. The Turks drove back the invaders, dealing the Allies a crushing defeat. However, the Allies won the war in 1918.

After World War I, the Allies set out to break up the Ottoman Empire. Allied troops occupied Istanbul and the Straits. In May 1919, Greek troops, protected by Allied fleets, landed at the Turkish port of Izmir. The Greeks then advanced into the country. The Turks deeply resented the Ottoman government's inability to defend their homeland.

Mustafa Kemal, a Turkish military hero, quickly organized a nationalist movement. Under the leadership of Kemal, a nationalist congress met in Sivas in September to form a new *provisional* (temporary) government. In April 1920, the congress organized the Turkish Grand National Assembly in Ankara and elected Kemal as Assembly president.

In August 1920, the sultan's government signed the harsh Treaty of Sèvres with the Allies (see **Sèvres, Treaty of**). The treaty granted independence to some parts of the empire and gave other parts to various Allied powers. The empire was reduced to Istanbul and a portion of Anatolia. As a result of the treaty, the sultan's popularity among the Turks declined further, while the power of Kemal and the nationalists grew. In September 1922, the nationalist forces finally drove the Greeks from the country. The Grand National Assembly then abolished the office of sultan, and the Allies agreed to draw up a new peace treaty with the nationalists. The Treaty of Lausanne, signed in 1923, set Turkey's borders about where they are today.

The republic of Turkey. The Grand National Assembly proclaimed Turkey to be a republic on Oct. 29, 1923, and elected Kemal as president. Kemal and other nationalist leaders believed that the new nation could not survive without sweeping social changes.

During the 1920's and 1930's, the government did away with such Islamic traditions as the Arabic alphabet, Muslim schools, the Islamic legal system, and the wearing of the veil by women and the fez by men. It abolished the religious and civil office of the caliph. It also outlawed *polygyny,* the practice of having more than one wife at the same time. Women received the right to vote and to hold public office. All Turks were required to choose a family name. At the same time, the Grand National Assembly gave Kemal his surname—*Atatürk,* which means *father of the Turks.*

Atatürk held enormous political power. He controlled the Assembly and could appoint and dismiss the prime minister and cabinet without its approval. However, some Turks opposed Atatürk's anti-Islamic policies. The Kurds revolted against them in 1925, but the government put down the uprising.

Atatürk served as Turkey's president until he died in 1938. Ismet Inönü then became president. Under Inönü's leadership, Turkey avoided entering World War II (1939-1945) until February 1945, when Germany's defeat seemed certain. Turkey joined the United Nations (UN) the same year.

After World War II, the Soviet Union demanded control of territory in eastern Turkey and the right to build military bases along the Straits. Turkish leaders turned to the Western powers for help. In 1947, U.S. President Harry Truman announced the Truman doctrine, under which the United States would provide aid to any country threatened by Communism. The United States gave Turkey millions of dollars in economic and military aid. In return for this help, Turkey allowed the United States to build and operate military bases on Turkish soil.

The Republican People's Party, established by Atatürk, had governed Turkey since the establishment of the republic. However, in 1950, the Democrat Party won a majority in the Grand National Assembly. Celal Bayar became president, and Adnan Menderes became prime

Kemal Atatürk founded the Republic of Turkey in 1923 and was its first president. In an attempt to modernize the nation, he introduced major cultural, political, and economic reforms.

minister. Unlike the Republicans, the Democrats encouraged foreign investments and wanted less government control of the economy. But by the late 1950's, a rise in the national debt and restrictions on freedom of speech had made the Democrat government unpopular.

The 1960's. Turkish military forces believed that the Democrat government had strayed too far from Atatürk's political principles. In 1960, army units led by General Cemal Gürsel seized control of the government and set up a provisional government. The military placed many former government leaders on trial. Prime Minister Menderes was hanged. President Bayar was sentenced to life imprisonment but was later released.

In 1961, Turkey adopted a new constitution. The provisional government then held free national elections. No party won a majority in the legislature. But two members of the Republican People's Party were chosen for the highest offices. Inönü became prime minister, and Gürsel became president. In 1965, the Justice Party won a majority in the legislature, and the party leader, Süleyman Demirel, became prime minister. Gürsel held office until 1966.

The Cyprus crisis. During the 1960's, Turkey and Greece nearly went to war over the Mediterranean island of Cyprus. In 1964 and 1967, fighting broke out on Cyprus between the island's Turkish minority and Greek majority. Outside peacemakers arranged a settlement. In 1974, Greek military officers overthrew the president of Cyprus. Turkish troops then invaded the island and captured much territory. The Turks on Cyprus later established a separate government. The Turks declared the captured territory an *autonomous* (self-governing) region in 1975, and an independent republic in 1983. See **Cyprus** (History).

Recent developments. High taxes, inflation, and political unrest have troubled Turkey since the late 1960's. At that time, radical groups of Turks began staging bombings, kidnappings, and murders in an attempt to overthrow the government. Since the mid-1970's, much fighting has taken place between secular and religious groups. Each group has accused the other of terrorist acts. Since 1984, the government has fought against Kurdish rebels in the southeast. The rebels want to form an independent state in that region.

Control of Turkey's government changed hands many times during the 1970's. In 1971, Prime Minister Demirel resigned under pressure from the military. A series of prime ministers then failed to form a stable government. In 1975, Demirel again became prime minister. In the late 1970's, the office passed back and forth between Demirel and Bülent Ecevit of the Republican People's Party several times. Demirel became prime minister in November 1979. In 1980, army leaders took control of the government and greatly reduced the civil disorder. A new Constitution was adopted in 1982. General Kenan Evren was named president until 1989 by a provision in the Constitution. Turkey returned to civilian rule in 1983 when parliamentary elections were held. Turgut Özal of the centre-right Motherland Party became prime minister. Özal and his party won a second general election in 1987. In 1989, the National Assembly elected Özal as president until 1996. Özal named Yıldırım Akbulut as prime minister. The general election of 1991 led to the return of Demirel, now leader of the True Path Party, as prime minister. In 1993, after the death of Özal, Demirel was elected president. Tansu Ciller succeeded him as leader of the party and became Turkey's first woman prime minister.

Related articles in ***World Book*** include:

Biographies

Atatürk, Kemal
Barbarossa
Muhammad II
Muhammad Ali
Suleiman I

Cities and towns

Ankara
Antioch
Edirne
Istanbul
Izmir
Tarsus

History

Armenia
Balkans
Berlin, Congress of
Byzantine Empire
Crimean War
Cyprus
Janissaries
Kurdistan
Ottoman Empire
Russo-Turkish wars
Seljuks
Sèvres, Treaty of
Sultan
Thrace
Turks
World War I

Physical features

Ararat
Bosporus
Dardanelles
Euphrates River
Marmara, Sea of

Other related articles

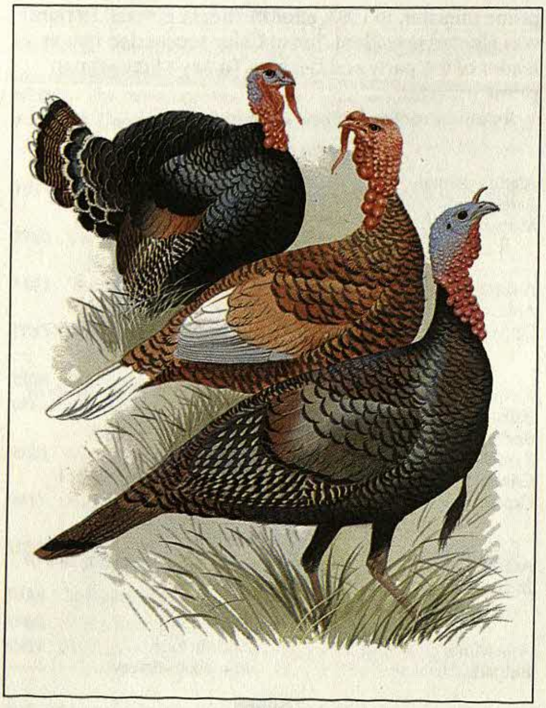
Asia Minor
Bulgaria (History)
Middle East
Romania (History)

Outline

- **I. Government**
  - A. The president
  - B. The prime minister and cabinet
  - C. The Grand National Assembly
  - D. Court system
  - E. Local government
  - F. Political parties
  - G. Armed forces
- **II. People**
  - A. Population and ancestry
  - B. Languages
  - C. Ways of life
  - D. Housing
  - E. Clothing
  - F. Food and drink
  - G. Recreation
  - H. Religion
  - I. Education
  - J. Arts
- **III. Land**
  - A. The Northern Plains
  - B. The Western Valleys
  - C. The Southern Plains
  - D. The Western Plateau
  - E. The Eastern Plateau
  - F. The Northern Mountains
  - G. The Southern Mountains
  - H. The Mesopotamian Lowlands
- **IV. Climate**
- **V. Economy**
  - A. Agriculture
  - B. Manufacturing
  - C. Mining
  - D. Foreign trade
  - E. Transportation and communication
- **VI. History**

Questions

What is Turkey's chief economic activity?
Why was a new Turkish language developed?
What are the *Straits*?
How has the role of Turkish women changed since 1900?
Who are the Kurds?
Who was Kemal Atatürk?
How did Atatürk's modernization programme revolutionize Turkish life during the 1920's?
Who were the Young Turks?
What are the chief foods of most Turks?
What was the Ottoman Empire?



Common varieties of turkeys include the Bronze, *shown at the top;* the Bourbon Red, *middle;* and the wild turkey, *bottom.*

Turkey is the name of two species of American birds related to chickens, peafowl, and pheasants. American Indians raised turkeys for food as early as A.D. 1000.

Male turkeys are called *toms,* and females are called *hens.* Male turkeys are sometimes known as *gobblers* from their habit of making a "gobbling" noise to impress the hen when mating. Baby turkeys are called *poults.* The two species of turkey are the *ocellated turkey* and the *North American turkey.* The ocellated turkey, which is also called the *Yucatán turkey,* inhabits Guatemala and the Yucatán Peninsula of Mexico. It is a brilliantly coloured bird that has eyelike spots on its tail. The North American turkey, which is also called the *common turkey,* inhabits the United States and certain areas in Mexico. This article discusses the North American turkey.

In general, wild turkeys have smaller heads and longer backs and legs than domestic turkeys do. Wild turkeys have stronger wings and legs that enable them to fly and run quickly. Domestic turkeys cannot fly.

Adult toms measure about 1 metre in length. Wild toms weigh from 4.5 to 7.5 kilograms. Some domestic toms weigh as much as 23 kilograms. The head and neck of toms are reddish and featherless. A long, loose piece of skin called a *wattle* extends from beneath the lower jaw along the neck. At the base of the neck are small, wartlike structures called *caruncles.* A long, beardlike tuft of bristly feathers hangs from the centre of the breast. Wild toms have plumage that is deep bronze in colour. The colour of domestic toms depends on variety.

Adult hens are dully coloured and have no bristly beards. They are smaller than adult toms. Wild hens weigh from about 3 to 4.5 kilograms. Some domestic hens weigh as much as 7.5 kilograms.

Wild turkeys gather in small flocks in the forests. They eat small nuts, seeds, insects, berries, and other small fruit. At night, wild turkeys rest in trees. They build simple nests of dry leaves on the ground. Turkey eggs are about twice as large as ordinary chicken eggs. They have a pale creamy-tan colour, speckled with brown.

The largest variety of domestic turkey is the *Bronze* turkey. The full-grown male weighs more than 19 kilograms and the young hen may weigh more than 9 kilograms. The Bronze turkey has the white tail-feather tips of its wild ancestor. Its feathers are dull black glossed with red and green on the front. They are bronze in the rear.

Toms reach market weight—approximately 11 kilograms—about 19 to 20 weeks after hatching. Hens are marketed at about 14 to 16 weeks of age, when they weigh about 4.5 to 5.5 kilograms.

Scientific classification. The turkey belongs to the family, Phasianidae. The ocellated turkey is *Agriocharis ocellata.* The North American turkey is *Meleagris gallopavo.*

See also **Agriculture** (picture: Poultry farming); **Poultry** (Raising poultry).

Turkey carving. See **Meat** (pictures).

Turkey red. See **Madder.**

Turkic peoples. See **Union of Soviet Socialist Republics** (People).

Turkish Angora cat. See **Cat** (Long-haired breeds; picture).

Turkmenistan is a mostly desert country in west-central Asia. For nearly 70 years, it had been one of the republics of the Soviet Union. It was called the Turkmen Soviet Socialist Republic, or Turkmenia. In 1991, Turkmenistan became independent. Turkmenistan lies in a broad, dry lowland extending east from the Caspian Sea. It covers 488,100 square kilometres. Most of the country is desert. The capital and largest city is Ashgabat. The official language is Turkmen, a Turkic language.

Government. Turkmenistan is a republic. It has a president as head of state and head of government, and a Cabinet of ministers to help carry out government operations. The voters elect the president to a five-year term. The president appoints the Cabinet members. The country also has a 50-member legislature called the Majlis, whose members are elected by the voters to five-year terms. Turkmenistan is divided into five regions for the purpose of local government.

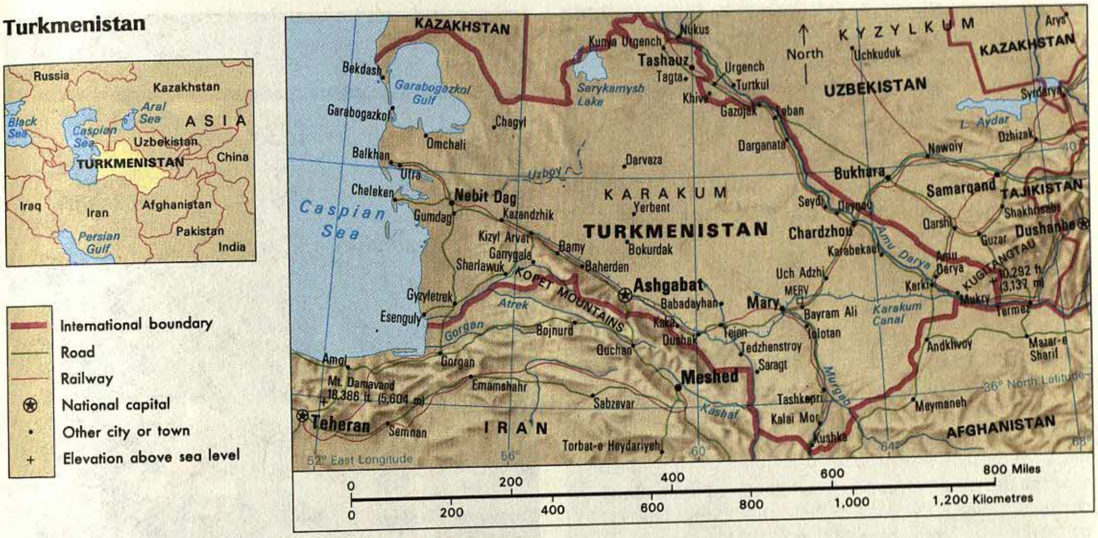
Turkmenistan's highest court is the Supreme Court. There are also regional courts and local courts.

People. For Turkmenistan's total population, see the *Facts in brief* table with this article. About 70 per cent of Turkmenistan's people are ethnic Turkmens, also called Turkomans, and about 10 per cent are Russians. Other ethnic groups include Uzbeks, Kazakhs, Tatars, Ukrainians, and Armenians.

The Turkmens are Sunni Muslims. Other religious groups in Turkmenistan include Shiite Muslims and Russian Orthodox Christians. Although most Muslims worship in mosques, Turkmens follow a special Muslim practice of worshipping primarily at tombs of holy men.

About 48 per cent of the people of Turkmenistan live in cities, and about 52 per cent live in rural areas. Most city dwellers live in red brick or limestone apartment

Turkmenistan



buildings. Some rural dwellers live in tentlike *yurts,* constructed of a wooden frame covered with felt.

Tribal organizations play an important role in Turkmenistan. Social life is centred on the family. In the countryside, many members of an extended family live together. Such a household might include parents, married children and their offspring, and other relatives. Some men have as many as four wives. Many Turkmens marry only within their own tribe.

People in Turkmenistan wear both Western-style and traditional clothing. Traditional dress for men includes a white shirt, dark trousers, and a red robe. Some men also wear a shaggy sheepskin hat. Women typically wear a long, loose dress trimmed with embroidery.

Turkmen dishes include *chorba* (a peppery meat soup); *chishlik* (meat roasted on a skewer); and *palov,* a rice dish. Milk products form an important part of the Turkmen diet. Turkmens drink green tea after meals.

Turkmens are known for weaving beautiful woollen carpets displaying geometric patterns in reds, yellows, and blues. Other crafts include embroidery, handmade fabrics, leathercraft, and jewellery.

Nearly all adults can read and write. Children attend school between the ages of 6 and 17. The country has one university and several schools of higher learning.

Land and climate. The Karakum desert covers more than 80 per cent of Turkmenistan. This vast desert is largely uninhabited. The Kopet-Dag mountains stretch along the south and southwest of the country. The Amu Darya river flows from mountains southeast of Turkmenistan into Uzbekistan, where it drains into the Aral Sea. Other rivers include the Murgab and the Tedzhen. The most heavily settled regions are the valleys of the Amu Darya, Murgab, and Tedzhen rivers, and the foothills of the Kopet-Dag mountains.

Summers in Turkmenistan are long, hot, and dry. Winters are cold. Desert temperatures range from about 35 to 50 °C in summer. Winter temperatures in the desert can drop below 0 °C. Turkmenistan receives about 8 to 30 centimetres of rainfall annually.

Economy. Agriculture accounts for almost half the value of Turkmenistan's economic production. Cotton, the chief crop, occupies more than 50 per cent of the farmland. Other farm products include grains, grapes, potatoes, wool, and *Persian lamb* (a fur taken from young lambs). Some Turkmens raise camels, pigs, a special breed of Turkoman horses, and Karakul sheep. Pelts from the sheep are highly prized for fur coats. Some farmers also raise silkworms.

Crops in Turkmenistan can only be grown by irrigation. An extensive system of canals moves water from the major rivers of the region to dry areas. The 1,200-kilometre long Karakum Canal transports water across the desert from the Amu Darya, past Ashgabat, to Kizyl-Arvat. Most of the farming regions in Turkmenistan lie along the Amu Darya and the Karakum Canal.

Manufacturing makes up about a fifth of the value of production in Turkmenistan. Chief manufacturing industries produce petrochemicals, cement, glass, and textiles of cotton, wool, and silk. Ashgabat, Balkhan, and Chardzhou are the country's industrial centres.

Turkmenistan's chief natural resources are natural gas

Facts in brief about Turkmenistan

Capital: Ashgabat.

Official language: Turkmen.

Area: 488,100 km². *Greatest distances*—east-west, 1,205 km; north-south, 845 km.

Elevation: *Highest*—Kugitangtau (mountain range), 3,137 m above sea level. *Lowest*—Garabogazkol Gulf, 31 m below sea level.

Population: *Estimated 1996 population*—4,260,000; density, 8 people per km²; distribution, 52 per cent rural, 48 per cent urban. *1989 census*—3,533,925. *Estimated 2001 population*—4,820,000.

Chief products: *Agriculture*—camels, cotton, grains, grapes, horses, pigs, potatoes, sheep. *Manufacturing*—cement, chemicals, glass, textiles. *Mining*—bromine, copper, gold, iodine, lead, mercury, natural gas, petroleum, salt, sodium sulphate, zinc.

Flag: The flag has three unequal vertical stripes of green, maroon, and green. On the maroon stripe are five different carpet patterns in black, white, maroon, and orange. To the upper right of the maroon stripe are five white stars and a white crescent. See **Flag** (picture: Flags of Asia and the Pacific).

Money: *Currency unit*—Turkmenian manat. One manat = 100 tenge.

and petroleum. The country has estimated reserves of 8,000 billion cubic metres of natural gas and 700 million metric tons of oil. Other resources include bromine, copper, gold, iodine, lead, mercury, salt, sodium sulphate, zinc, and such building materials as sand and limestone.

Under Soviet control, the government owned most of Turkmenistan's businesses, factories, and farmland. The economy of independent Turkmenistan is still largely controlled by government.

Turkmenistan has a limited road and railway system, linking only major urban areas. An airport at Ashgabat handles all flights to and from Turkmenistan.

A radio station and a television station broadcast out of Ashgabat in Turkmen and Russian. Newspapers and magazines are published in the same two languages.

History. People have lived in the area now known as Turkmenistan for thousands of years. The earliest inhabitants were probably nomads who lived by raising livestock in the desert areas and farmers who lived along rivers and oases. Persians of the Achaemenid Empire ruled the area from about 500 to 331 B.C., when Alexander the Great gained control of much of their empire. The kingdom of Parthia controlled the region between about 250 B.C. and A.D. 224, followed by Persians of the Sassanid dynasty. In the mid-600's, Muslim Arabs invaded the area.

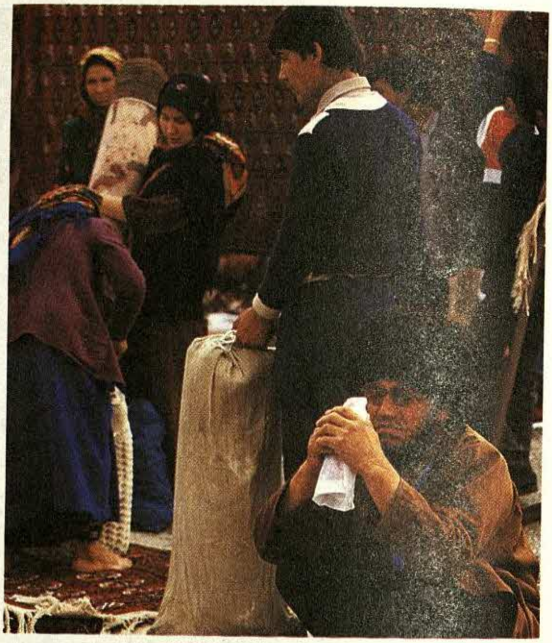
Turkic tribes began moving into Central Asia in about the 500's. By the 900's, some had settled in the area of Turkmenistan. The term *Turkmen* dates from this period. These tribes ruled until the Mongols, led by Genghis Khan, invaded the region in the early 1200's. By the 1300's, Islamic missionaries called *Sufis* had established Islam, the Muslim religion, in the region.

In the late 1300's, the Turkic conqueror Tamerlane made the area part of his vast empire. Between the 1400's and 1600's, the Safavids, a Turkish tribe, controlled the southern part of what is now Turkmenistan. Uzbek tribes spread through the region in the 1400's and briefly set up an empire in the 1500's. In the 1800's, an alliance of Turkic tribes called the Tekke Confederation gained control of the area.

Russia began a conquest of the region in the mid-1870's. By 1885, all Turkmen lands were under Russian control. Communists gained control of Russia in 1917. In 1922, the Soviet Union was formed under Russia's leadership. In 1924, after much resistance from local tribes, Turkmenistan became a republic of the Soviet Union called the Turkmen Soviet Socialist Republic.

The Soviets made many changes in Turkmenistan. They built roads, schools, housing, hospitals, and communications systems. The Soviets *collectivized* agriculture—that is, they ended private farming and transferred control of farms and livestock to the government. They also tried to discourage religious worship and suppress much of traditional Turkmen culture.

In the 1980's, the Soviet government instituted reforms that gave people more freedom. Opposition groups began criticizing government policies and poor economic conditions in the late 1980's. In 1990, Turkmenistan declared that its laws overruled those of the Soviet Union. In October 1991, the republic declared its independence. In December, following the collapse of the Soviet Union, Turkmenistan joined a loose association of former Soviet republics called the Commonwealth of Independent States.



Turkmen carpet vendors, *above,* peddle their wares at a market in Ashgabat, Turkmenistan's capital. Turkmen carpets are known for their beautiful geometric patterns in reds and blues.

In May 1992, Turkmenistan adopted a new constitution, which banned all political parties except the Democratic Party of Turkmenistan. In June 1992, Saparmurad Niyazov, who had been president of the former Turkmen Soviet Socialist Republic, was elected president.

See also **Commonwealth of Independent States.**

Turks are people who speak Turkic languages. There are about 10 Turkic languages. The main one is Turkish. Almost half of the approximately 90 million Turks in the world live in Turkey. Many others live in the central Asian lands of Azerbaijan, Kazakhstan, Kyrgyzstan, Turkmenistan, and Uzbekistan. In addition, there are sizable communities of Turks in Afghanistan, China, Iran, Mongolia, and Russia. Some Turks also live in the Balkan countries of southeastern Europe.

Turks make up a vast majority of the people in Turkey. Turks also form a majority of the population in much of central Asia. The central Asian Turks include members of the Tatar and the Kyrgyz ethnic groups. Most Turks are *Muslims* (followers of Islam).

The Turks have had an important history. Their ancestors include the Huns and other nomadic people from Asia. The Huns conquered much of Europe during the A.D. 400's. During the 1000's, the Seljuk Turks seized Persia (now Iran) and then took over Asia Minor (now Turkey). The Ottoman Turks settled in Asia Minor during the late 1200's. By the 1500's, they had gained control of most of the Middle East, northern Africa, and southeastern Europe. The Ottomans were defeated in World War I (1914-1918). The modern nation of Turkey came into being in 1923.

See also **Ottoman Empire; Seljuks; Tatars; Turkey.**

Turks and Caicos Islands are a dependency of the United Kingdom (UK) in the northern Caribbean Sea. The dependency consists of about 30 islands and *cays* (low sand banks) in the West Indies. It lies about 50 kilometres southeast of the Bahamas and about 140 kilometres north of Hispaniola. The territory comprises two distinct island groups. The Turks Islands, to the east, consist of Grand Turk and Salt Cay, together with a number of small uninhabited cays. The Caicos Islands lie to the west and include South Caicos, East Caicos, Middle Caicos, North Caicos, Providenciales, and West Caicos. A deep channel, 32 kilometres wide, called the Turks Passage, separates the two island groups.

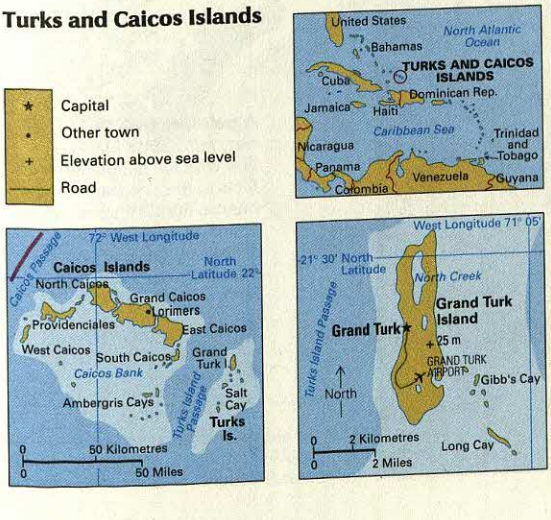
Government. The government consists of an *executive council* and a *legislative council*. The governor, appointed by the monarch of the UK on the advice of the UK government, presides over the executive council, consisting of the chief minister and seven other members. The Legislative Council is made up of 13 elected members, three appointed members, and three officials who are also members of the executive council.

People. The Turks and Caicos have a population of 7,400, 32 per cent residing in Grand Turk and 42 per cent located in Providenciales. Most of the inhabitants are of African origin. Providenciales (commonly known as Provo) is the most cosmopolitan of the islands. Many Europeans and Americans live there. English is the official language. But many Haitian immigrants live in the Turks and Caicos, and they speak a French creole.

Land and climate. The Turks and Caicos are barren, sandy islands. They cover a total land area of 430 square kilometres. Providenciales is the centre of the islands' development and the site of the international airport. Middle Caicos, also called Grand Caicos, is the largest inhabited island. It is 50 kilometres long and measures 5 kilometres at its widest point. Sparsely populated, its main attractions are large caves containing stalagmites and stalactites. Rainfall varies from 50 centimetres a year in the easterly islands to 100 centimetres a year in the west.

Economy. Tourism and financial services form the mainstays of the local economy. The islands' sandy beaches and such annual events as the South Caicos Regatta attract many overseas visitors. Tourists may also enjoy carnivals in Providenciales in July and in Grand Turk in August.

Turks and Caicos Islands



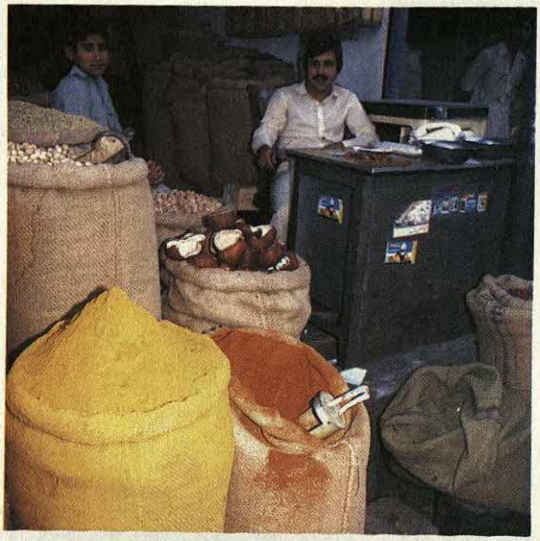
Grand Turk is one of the Turks and Caicos Islands, a group of some 30 islands in the Caribbean Sea.

Financial services are more important to the economy than tourism. Many foreign investors place their funds with banks in the Turks and Caicos. Fishing continues to be important. The islands export conchs and lobsters to the United States.

History. A people called the Lucayo, migrants from Venezuela, were the first inhabitants of the Turks and Caicos. Many historians think that, in 1512, the Spanish commander Juan Ponce de León became the first European to visit the islands. Recent historical articles, however, suggest that the Turks and Caicos, rather than the Bahamas, could have been the first Caribbean territory on which Columbus landed in 1492.

The Spaniards ignored the islands. The first people to colonize them were Bermudians, British subjects who arrived in 1678 to develop the salt industry. The islands were for a long time administered from the Bahamas but, by 1848, they had their own governing council. They were later administered from Jamaica but were separated when the latter became independent in 1962. The islands then became a separate UK dependency. The present ministerial system of government was introduced in 1976.

In 1986, alleged government corruption led to the reimposition of direct rule from the United Kingdom. But by 1988, a new Constitution provided for internal self-rule.



Turmeric roots produce a yellowish powder that is aromatic and has a strong, pungent taste. It is mainly used for dyeing.

Turmeric is a plant that grows in southern Asia. Its fleshy roots are the source of a substance, also called turmeric, which is used mainly for dyeing. These roots are hard and tough. On the outside, they are brownish- or yellowish-green. When they are broken, they show a resinous interior that varies from orange-brown to deep reddish-brown. The roots are ready for the market after being cleaned, boiled for some hours, and then dried in an oven. The yellowish powder that they yield when ground has a strong odour and a pungent taste.

Turmeric has been used for hundreds of years as a dyestuff and as a spice. It is an important ingredient of curry powder and is used to colour mustard (see **Curry**). It does not yield a fast colour, however, as a dyestuff. It has gone out of use as a medicine, but in India people mix it with milk to form a cooling lotion for the skin and eyes. Turmeric is useful in chemistry in making test papers for alkalis. With the addition of alkali, white paper soaked in a tincture of turmeric turns to reddish-brown and, on drying, to violet.

Scientific classification. Turmeric belongs to the ginger family, Zingiberaceae. It is classified as *Curcuma longa.*

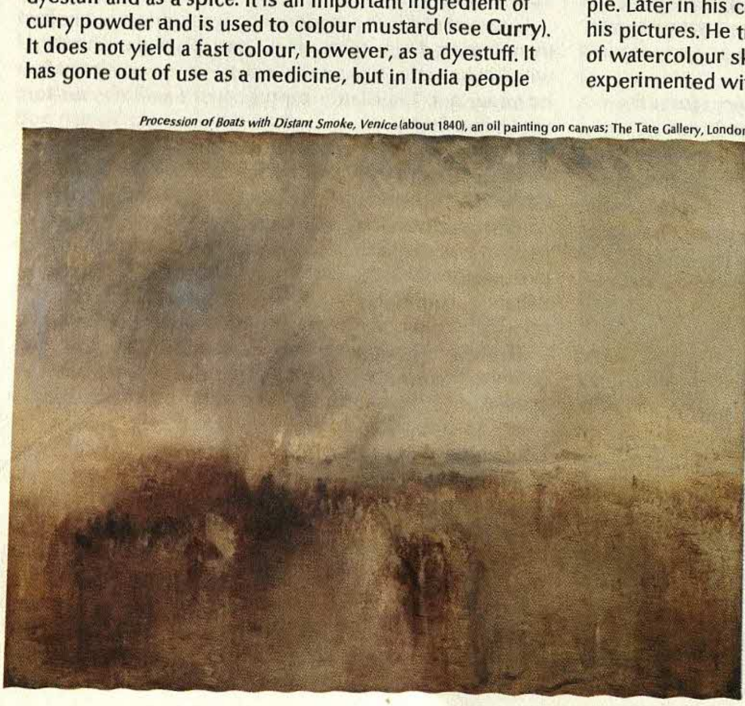
Turner, Ethel (1872-1958), an Australian author, wrote *Seven Little Australians* (1894). The story has been published in 38 editions totalling more than a million copies. It has been translated ten times, dramatized, broadcast, filmed, and televised. Ethel Turner was born in Doncaster, England. She arrived in Australia as a child. She wrote many other novels as well as verse and stories.

Turner, J. M. W. (1775-1851), was perhaps the greatest landscape painter in the history of English art. In many oil paintings and watercolours, Turner departed from traditional ways of dealing with atmosphere, light, and colour. Earlier artists had treated such elements realistically. In Turner's works, forms and outlines seem to dissolve into shimmering mist, steam, or smoke, or into the intense light of bright sky or water. By changing the way artists represented reality, Turner began a process continued by the impressionists and many other artists of the late 1800's and the 1900's.

Joseph Mallord William Turner was born in London. He began art training at the Royal Academy of Arts at the age of 14 and became an accomplished watercolourist. His early style shows the influence of the English artists J. R. Cozens and Thomas Girtin. The young painter was also influenced by the landscapes of the French painters Nicolas Poussin and Claude. Beginning in 1790, Turner exhibited at the Royal Academy, London. He was elected a member of the academy in 1802.

Turner's early paintings emphasize drama and romance. His oil painting *The Shipwreck* (1805) is an example. Later in his career, Turner stressed atmosphere in his pictures. He travelled widely, producing thousands of watercolour sketches. In many of these sketches, he experimented with the brilliance of colour. During the

Procession of Boats with Distant Smoke, Venice (about 1840), an oil painting on canvas; The Tate Gallery, London



A painting by J. M. W. Turner, *left,* shows his fascination with the atmospheric effects of the sky, water, and intense light. This painting is one of many shimmering scenes of Venice, Italy, that Turner painted late in his career.

1830's and 1840's, Turner painted a series of watercolour views of Venice that rank among his masterpieces. Turner achieved a colourful, abstract quality in such oil paintings as *The Slave Ship* (1840) and *Rain, Steam, and Speed—The Great Western Railway* (1844). Many of his oil paintings reveal his fascination with the visual effects of fire and water. A famous example, *Burning of the Houses of Parliament* (about 1835), appears in **Painting** (Romanticism).

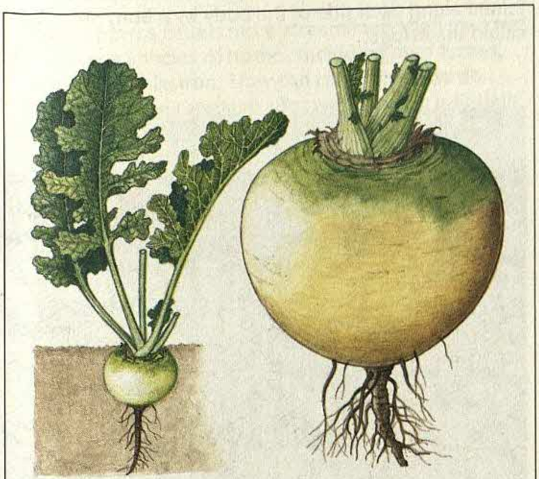
See also **Ruskin, John.**

Turner, Nat (1800-1831), a black slave and preacher, led the most famous slave revolt in United States history. In 1831, Turner and from 60 to 70 other slaves killed about 60 whites in Virginia. More whites died during the rebellion than in any other in the history of the United States. The Virginia militia captured and hanged about 20 of the slaves, including Turner. In addition, angry whites killed about 100 innocent slaves. The rebellion caused the Southern States to pass strict laws for the control of slaves.

Turner was born on a plantation in Southampton County, Virginia. His parents and grandmother encouraged him to become educated and to fight slavery. Over the years, Turner became the property of several other slaveowners. The son of one of his masters taught him to read and write. Turner became known as a forceful preacher who believed that God wanted him to free the slaves. This conviction led to his planning the rebellion.

Turnip is a vegetable grown for its fleshy root and green leaves. Most turnip roots are globe-shaped. In most cases, they measure from 5 to 8 centimetres in diameter when harvested and weigh between 225 and 450 grams. Their smooth, firm flesh may be white or light yellow. The thin, hairy leaves of the turnip plant grow on stems that can reach a height of about 45 centimetres.

Turnips consist of about 90 per cent water. The roots are a good source of vitamin C and the leaves are rich in iron and vitamin A. Turnip roots are boiled, mashed, and served with seasonings or sauce. The leaves are used in salads, soups, and stews. Cooked turnip leaves, called *turnip greens,* are popular in many countries.



Turnips are grown for their edible leaves and roots. The leaves grow on stems, *above left.* The edible part of the root is globe-shaped and consists of smooth, firm flesh, *above right.*

There are several varieties of turnips. The *swede,* or Swedish turnip, is a vegetable closely related to the turnip. It is sometimes called a rutabaga (see **Swede**).

Turnips are grown throughout Europe and North America. The yellow-fleshed varieties are considered to keep better in winter storage. Turnips thrive in cool weather, and withstand light frost. The plants grow quickly and are usually ready for harvest 45 to 55 days after planting. The seeds are planted in time for a spring or for an autumn harvest. Turnip seeds develop best in moderately dry, loose soil. They are usually planted about 1.5 centimetres deep and about 5 to 10 centimetres from one another in rows at least 30 centimetres apart. Turnips require large amounts of fertilizer, especially when planted in the spring. Aphids, cabbage worms, and various beetle larvae are the chief pests that attack turnip roots and leaves.

Turnips probably originated in Asia or Europe. The ancient Greeks and Romans grew turnips and may have introduced them into northern Europe. Turnips have been popular in England since the 1500's.

Scientific classification. The turnip plant is in the mustard family, Cruciferae (Brassicaceae). It is *Brassica rapa.* The swede is *B. napo-brassica.*

Turnsole. See **Heliotrope.**

Turnstone is the name given to two kinds of small shore birds. The name refers to their habit of turning over shells and pebbles with their bills as they look for food. The *ruddy turnstone* nests on *tundras* (treeless plains) in arctic regions worldwide. In winter it flies as far south as South America, Africa, and Australia, reaching both the Atlantic and the Pacific coasts of the United States in its migrations. It is about 23 centimetres long, with black, white, and reddish-brown feathers in a complex pattern. The pattern helps camouflage the bird when it sits on its nest on the ground. The *black turnstone* is slightly larger and lacks the reddish colour. It nests along the shores of the Bering Sea in Alaska, and winters from southeastern Alaska to Lower California—the peninsula of Baja California, in Mexico.

Scientific classification. Turnstones belong to the sandpiper family, Scolopacidae. The ruddy turnstone is *Arenaria interpres.* The black turnstone is *A. melanocephala.*

Turpentine is a colourless or yellowish liquid that has a strong odour and is highly flammable. It is used chiefly in making such chemical products as disinfectants, insecticides, medicines, and perfumes and in making synthetic rubber. It is also used as a thinner in paints and varnishes and for removing paint stains from clothing and the skin. Some turpentine is used in the processing and flavouring of certain foods. Turpentine is made chiefly from longleaf pines and slash pines, which grow throughout the Southeastern United States.

Turpentine is the name of an Australian tree. It is called *turpentine* because a fragrant, gumlike resin similar to commercial turpentine oozes from cuts in the bark. But it does not provide the turpentine used in industry. The tree grows 40 to 45 metres in height. The timber is very resistant to *termites* (white ants). It is used for salt water piles and other heavy construction.

Scientific classification. Turpentine belongs to the family Myrtaceae. It is *Syncarpia glomulifera.*

Turpin, Dick (1706-1739), was an English robber whose exploits have appeared in English legends and literature. As a youth, he joined a band of thieves who stole farm animals and deer. Later, he worked with Tom King as a highwayman, robbing travellers along the road from London to Oxford. He accidentally killed King while shooting at a policeman. Finally, Turpin was arrested in York, England, for stealing horses, was found guilty, and was hanged. William Ainsworth's novel *Rookwood* (1834) described Turpin's famous ride from London to Yorkshire on his horse, Black Bess. The story of this ride was originally told of an earlier highwayman named "Nicks." Richard Turpin was born in Hempstead, Essex, England, the son of an innkeeper.

Turquoise is a mineral widely used as a gemstone. It is prized for its colour, which ranges from bright blue to blue-green. Turquoise is relatively soft, and so it is easy to shape and polish. It has a dull, waxy lustre and is nearly *opaque* (nontransparent).

Turquoise consists chiefly of a *hydrous aluminium phosphate,* a compound in which aluminium and phosphorus are chemically combined with water. Turquoise also contains copper. The copper gives the mineral its bluish colour.

Turquoise occurs in arid regions. It is formed when surface rocks that are rich in aluminium undergo a chemical change. In most cases, turquoise results from the weathering of lava. Major deposits of turquoise are found in Iran and Tibet.

People have used turquoise for jewellery and other decorative purposes since ancient times. It is one of the December *birthstones* (see **Birthstone**). The demand for turquoise remains so great that artificial varieties of the stone are produced.

Turtle is a reptile with a shell, which lives mainly in water. Most *species* (kinds) of turtles can pull their head, legs, and tail into their shell, which serves as a suit of armour. Few other backboned animals have such excellent natural protection.

Turtles, like all reptiles, are cold-blooded—that is, their body stays about the same temperature as that of the surrounding air or water. Turtles cannot be warm or active in cold weather, and so they cannot live in regions that are cold throughout the year. Unlike tortoises, which live only on land, turtles spend almost their entire lives either in fresh water or in the sea. Many turtles spend their whole life within a few kilometres of the place where they hatched. But others migrate thousands of kilometres from their birthplace.

Turtles vary greatly in size. The largest species, the marine *leatherback turtle,* grows to between 1 and 2.5 metres long. But the North American *common bog turtle* measures only about 10 centimetres in length.

Turtles can swim rapidly. One marine species, the *green turtle,* can swim for brief periods at over 30 kilometres per hour. On land, turtles are slow, lumbering creatures, but some species can move with surprising speed. For example, the *smooth softshell turtle,* a freshwater species of North America, can outrun a person on level ground.

The first turtles lived more than 185 million years ago. *Archelon,* a sea turtle of about 25 million years ago, grew to a length of over 3.5 metres. This creature died out, as did many other species. Today, many species of turtles face extinction because people hunt them for food and for their shells, and gather their eggs. People also destroy their habitats to make way for cities and farms.

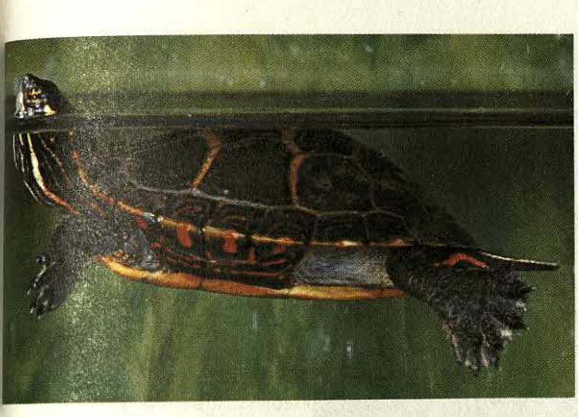
The body of a turtle

Shell. Most species of turtles can pull their head, legs, and tail into their shell for protection. A few kinds of turtles cannot withdraw into their shell.

A turtle's shell consists of two layers. The inner layer is made up of bony plates and is actually part of the skeleton. Among most species, the outer layer consists of hard, horny structures called *scutes,* which are formed from skin tissue. Soft-shelled turtles and the leatherback turtle have an outer layer of tough skin rather than scutes. The part of the shell that covers the turtle's back is called the *carapace,* and the part that covers the belly is called the *plastron.* The carapace and the plastron are joined along each side of the body by a bony structure called the *bridge.*

The hawksbill turtle is a sea turtle that lives in shallow water, not far from land. It was once hunted on a large scale for its rich-coloured and patterned shell, called *tortoiseshell.*

The Pacific ridley turtle grows to nearly 80 centimetres long. Mass nesting of Pacific ridley turtles occurs along the coast of Orissa province, India.



Turtles live in a variety of habitats. The painted turtle, *top,* makes its home in fresh water. It uses its webbed feet for both swimming and walking. The green turtle, *bottom,* dwells in the sea. It has long, paddlelike flippers.

Turtles have a flatter, more streamlined shell than tortoises. Some species of turtles, including mud turtles, have a hinged plastron. They can close the plastron tightly against the carapace after withdrawing into their shell.

The shells of most kinds of turtles are plain black, brown, or dark green. But turtles have bright green, orange, red, or yellow markings.

Head. The head of most species of turtles is covered by hard scales. Turtles have no teeth, but they have a beak with a hard, sharp edge that they use to cut food. Many turtles have powerful jaws, with which they tear food and capture prey.

Legs and feet. The legs and feet of turtles differ according to the habitat of the species. Most freshwater turtles have long legs and webbed feet. Sea turtles have paddle-shaped legs, with flippers instead of feet.

The hip bones and shoulder bones of turtles, unlike those of any other animal, are inside the ribcage. This unusual feature enables most kinds of turtles to pull their legs inside their shell. The species that are unable to withdraw their legs cannot do so because the shell is too small.

Senses. Turtles have a well-developed sense of sight and of touch. Scientific experiments indicate that they also have a good sense of smell, at least for nearby objects. Turtles have a middle ear and an inner ear, and a *tympanic membrane* (eardrum) forms their outer ear. A turtle can hear low-pitched sounds about as well as a human being can.

The life of a turtle

Young. Turtles hatch from eggs, which are fertilized within the female's body. One mating can result in the fertilization of all the eggs of a female for several years. Most kinds of turtles lay their eggs between late spring and late autumn, and some lay eggs more than once during this period. For example, a green turtle may lay as many as seven *clutches* (groups) of eggs during one breeding season.

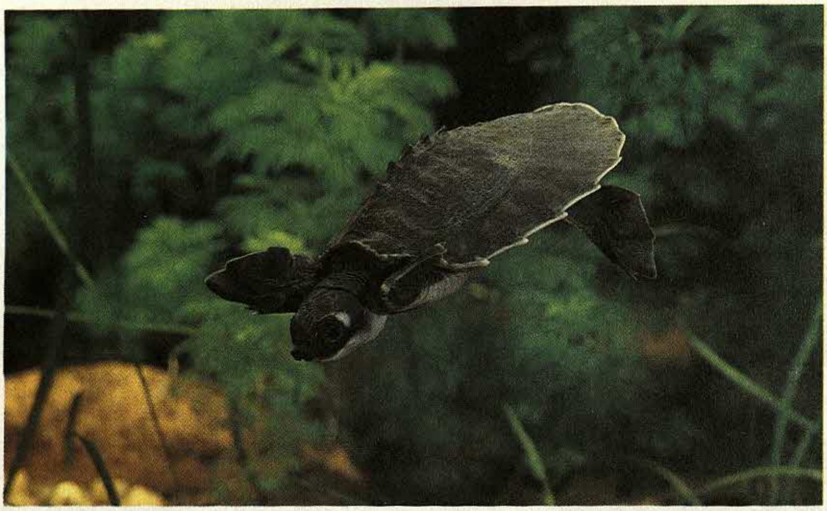
All turtles, both sea and freshwater species, lay their eggs on land. In most species, the female digs a hole in the ground with her back feet when ready to lay her eggs. She lays the eggs in the hole and covers them with soil, sand, or rotting plant matter. The number of eggs laid varies. A sea turtle may lay 200 eggs at a time. A green turtle may lay over 1,000 eggs in one breeding season.

The female turtle walks away after covering her eggs and does not return. The warmth of the sun hatches the eggs. The temperature at which the eggs are incubated also determines the sex of the hatchlings. Newly hatched turtles must dig their way to the surface of the ground, obtain food, and protect themselves—all on their own.

Many animals prey on turtle eggs and newborn turtles. Various birds and mammals flock to beaches and eat baby sea turtles as they crawl toward the water. Fish attack many others as they enter the sea. Both animals and people dig up the nests of freshwater turtles and devour the eggs.

Scientists believe turtles live longer than any other backboned animal. Some turtles have been known to live for more than 100 years. Most of a turtle's growth occurs during the animal's first 5 to 10 years. The turtle continues to grow after reaching this age, but at a much slower rate.

The mud turtle can be identified by its smooth, rounded *carapace* (back shell). It is about 9 centimetres long. The mud turtle lives in the eastern and southern United States.



The pig-nosed soft-shelled turtle has flippers like those of sea turtles. It is the only member of the family Carettochelyidae, and lives in rivers and lagoons of northern Australia and southern Papua New Guinea.

Food. Most turtles eat both animals and plants. The diet of turtles varies among the species. A few kinds of turtles, including green turtles, feed almost entirely on plants. Certain freshwater species, such as map turtles and soft-shelled turtles, eat chiefly animals.

Hibernation. Species that live in regions with harsh winters must hibernate. Most freshwater turtles hibernate by burrowing into the warm, muddy bottom of a pond, stream, or other body of water.

Some species of turtles survive hot, dry periods by going into a state of limited activity called *aestivation.* Aestivation somewhat resembles hibernation.

Kinds of turtles

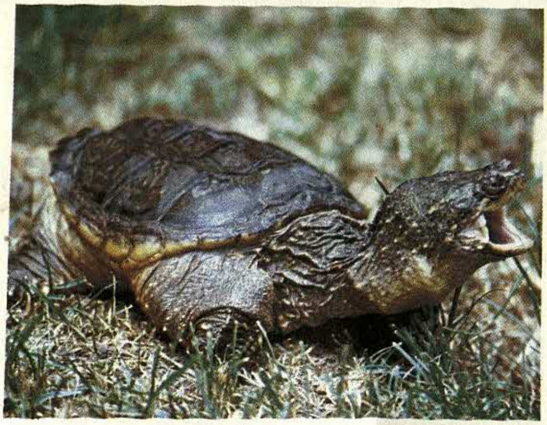
There are six main groups of turtles: (1) mud and musk turtles, (2) pond and marsh turtles, (3) sea turtles, (4) side-necked turtles, (5) snapping turtles, and (6) soft-shelled turtles.

Mud and musk turtles make up a family of 22 freshwater species. They live in North and Central America. Mud and musk turtles include the *common mud turtle* and *common musk turtle.*

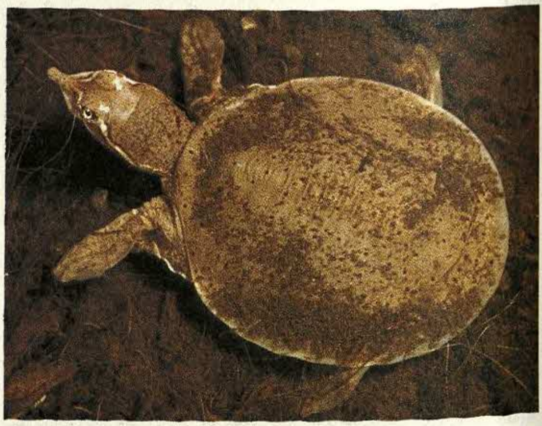
Few mud and musk turtles grow more than 15 centimetres long. But these turtles have large heads and strong jaws, and they may bite. When disturbed, these turtles give off a foul-smelling substance called *musk* from glands on the bridge in front of their hind legs. The common musk turtle, whose musk has a particularly strong, unpleasant scent, is often called the "stinkpot."

Pond and marsh turtles form the largest family of turtles—about 90 species. Members of this family live in Asia, Europe, North and South America, and northern Africa. Many species are brightly coloured, with green, red, or yellow markings on their head, legs, and shell. Most pond and marsh turtles are small, but some kinds may grow to more than 30 centimetres long. The majority of pond and marsh turtles live in lakes, ponds, rivers, streams, and tidewater areas.

Sea turtles. There are at least seven species of sea turtles. Six of them—the *green turtle,* the *flatback,* the *hawksbill,* the *loggerhead,* the *Atlantic ridley,* and the *Pacific ridley*—have bony, scute-covered shells. Most zoologists classify these species into one family. The seventh species, the *leatherback,* forms its own family. Its



The common snapping turtle has a small shell in relation to the rest of its body. The snapper cannot retreat into its shell for protection, and so it depends on its strong jaws for defence.



A soft-shelled turtle has a round, flat shell covered by leathery skin. Most soft-shelled turtles also have paddlelike legs and a long, flexible nose that serves as an underwater breathing tube.

shell has far fewer bones than that of the other sea turtles and is covered with skin rather than scutes. Most sea turtles live in warm seas throughout the world. The leatherback often ventures into colder waters.

Sea turtles rank among the largest species. Even the smallest ones, the ridleys, grow up to about 70 centimetres long and weigh nearly 45 kilograms. A leatherback may measure 2.5 metres long and weigh 680 kilograms. Sea turtles swim by beating their flippers much as a bird flaps its wings. Other turtles swim with a back-and-forth paddling motion. Sea turtles cannot withdraw into their shell, and so they depend on their size and swimming speed for defence.

Female sea turtles do not normally leave the water except to lay their eggs. Most of the males never return to land after entering the sea as hatchlings. The females often migrate thousands of kilometres to reach their breeding beaches. They drag themselves onto a sandy beach, bury their eggs, and then return to the sea. They are almost completely helpless while they are on land.

Side-necked turtles bend their neck sideways when withdrawing their head, instead of pulling straight back into their shell. There are about 55 species of these turtles, which are divided into two families. They live in Africa, Australia, and South America, mainly in areas south of the equator. The *Western swamp turtle* of Australia is one of the rarest of the world's turtles. Less than 30 are thought to exist in the wild.

Snapping turtles make up a family of large, freshwater turtles that live only in North America, Central America, and northern South America. There are two species of snappers. The *common snapper* may grow to more than 45 centimetres long. The *alligator snapper* is the largest turtle of North America, except for sea turtles. An alligator snapper may measure more than 60 centimetres long and weigh over 90 kilograms.

Snapping turtles eat small water animals, such as fish, frogs, insects, snails, and young waterfowl. They also feed on plants and *algae* (simple aquatic organisms). Snappers have a large head and strong jaws. They have a small shell that does not give much protection, and so they depend on their strong, sharp-edged jaws for defence.

Soft-shelled turtles make up a family of 21 species. These freshwater turtles have a shell covered by smooth skin. Their shell is flatter than that of other turtles, enabling them to hide in the mud at the bottom of a pond or river. They live in Africa, Asia, and North America.

Unlike other turtles, soft-shelled turtles have fleshy lips that cover their beak. Most kinds of soft-shelled turtles also have a long, tube-shaped nose that they push above the surface of the water in order to breathe. Most species do not grow much longer than about 30 centimetres, but some measure up to about 90 centimetres long. A soft-shelled turtle may bite when disturbed.

Tortoises form a family of about 40 species. These land turtles live in Africa, Asia, Europe, and North and South America, and on certain ocean islands. The tortoises of the Aldabra Islands and the Galapagos Islands are the world's largest land turtles. These huge reptiles may measure up to about 1.5 metres long and may weigh up to 250 kilograms.

Tortoises have strong, thick legs and short, unwebbed toes. Their front legs may be flattened and scooplike for digging. In this they differ from other turtles, and many people consider the term land turtle to be incorrect. Most tortoises are *herbivores* (plant eaters).

Tortoises live only on land. Most species are slow-moving creatures with a high, domed shell. In cold weather, tortoises may sleep under twigs and leaves or, in some areas, dig a hole to hibernate in. In places where the weather is hot, a tortoise will need to cover itself in damp mud to keep cool (see **Reptile**).

Turtles and human beings

The activities of human beings are a serious threat to the survival of many turtles, and turtle conservation must improve to prevent certain species from becoming extinct. Wildlife experts classify more than 50 kinds of turtles as endangered or threatened. These rare turtles include most sea turtles.

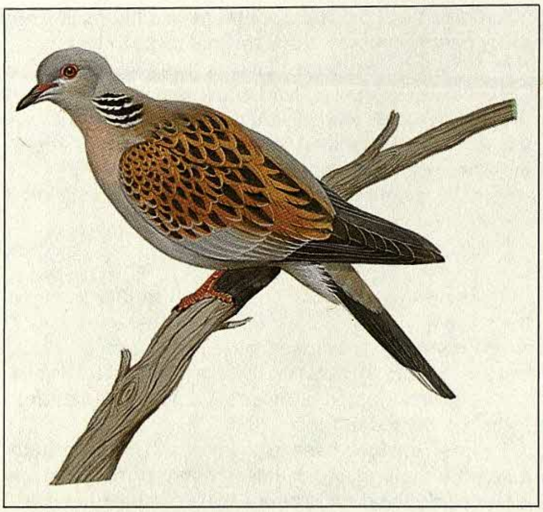
People have long used turtle meat and eggs for food and turtle shells as ornaments. The most threatened species include the most economically valuable ones. For example, the green turtle is a popular food in many parts of the world. The use of its meat and eggs by humans has seriously endangered its survival. The hawksbill turtle also has almost been killed off because *tortoiseshell,* a substance used in making ornamental objects, comes from its carapace. People further endanger turtles by poisoning their homes with pollution. They also continually replace forests, swamps, and other natural areas with cities and farms. This action almost ensures the extinction of certain kinds of turtles.

Some governments forbid the capture of rare species of turtles. Turtle reserves have been established in certain areas, and scientists are experimenting with raising valuable species on turtle farms. But zoologists must know more about how turtles live in the wild to save many of the endangered ones.

Scientific classification. Turtles belong to the class Reptilia, order Chelonia. The common mud turtle is *Kinosternon subrubrum;* the common musk turtle is *Sternotherus odoratus.* Pond and marsh turtles belong to the family Emydidae. The bog turtle is *Clemmys muhlenbergii.* There are two families of sea turtles. The leatherback belongs to the family Dermochelyidae. It is *Dermochelys coriacea.* Other marine turtles belong to the family Cheloniidae. The green turtle is *Chelonia mydas,* the flatback *C. depressa;* the hawksbill is *Eretmochelys imbricata;* the loggerhead is *Caretta caretta;* and the Atlantic ridley is *Lepidochelys kempi,* and the Pacific ridley *L. olivacea.* Side-necked turtles belong to the families Chelidae and Pelomedusidae. The Western swamp turtle belongs to the former family, it is *Pseudemydura umbrina.* Snapping turtles belong to the family Chelydridae. The common snapper is *Chelydras serpentina* and the alligator snapper is *Macroclemmys temminckii.* The soft-shelled turtles are in the family Trionychidae. The smooth soft-shell turtle is *Trionyx muticus.*

See also **Terrapin; Tortoise.**

Turtle dove is a small dove that breeds in woodland and open country in Europe, western Asia, and northern Africa. Turtle doves migrate, often in flocks, south to central Africa in winter. They fly swiftly and directly, with a flickering wing action. The turtle dove feeds on seeds of weeds and grains. Its purring coo is a common sound in spring. The turtle dove nests in thickets and orchards. The female generally lays two eggs on a thin platform of twigs and grass. Both parents provide care for the young. The mourning dove of North America is sometimes wrongly called a turtle dove.



The turtle dove is a slender bird known for its soft cooing call. It lives in Europe, northern Africa, and western Asia.

Scientific classification. The turtle dove belongs to the pigeon and dove family, Columbidae. It is *Streptopelia turtur.*

Tuscany is a political region, or state, in Italy. Its Italian name is Toscana. Tuscany lies on the western coast of Italy, and north of the city of Rome. It is made up of nine provinces. It covers an area of about 22,990 square kilometres, and has a population of about 3,570,926. Tuscany is an important agricultural and industrial centre. Tuscan straw hats are known all over the world as *Leghorns.* Tuscany has the famous Italian cities of Florence, Pisa, Siena, and Leghorn (Livorno).

Tuscany has long been an important Italian centre of art and learning. In early times, the territory was the home of an ancient people known as *Etruscans.* The Italian poets, Dante and Petrarch, used the language of Tuscany for their poems.

See also **Etruscans; Florence; Siena.**

Tusk. See **Boar, Wild; Elephant; Pig** (Teeth).

Tussaud, Madame. See **Tussaud, Marie Gresholtz.**

Tussaud, Marie Gresholtz (1761-1850), a Swiss modeller in wax, founded Madame Tussaud's Exhibition in London in 1802. Her descendants still maintain this famous museum of wax figures of prominent people. Some of the exhibits were modelled from life by Madame Tussaud and members of her family. Additional figures for the museum are made each year.

Marie Gresholtz was born in Bern, Switzerland, and learned to model in her uncle's museum in Paris. In 1794, she married François Tussaud. During the French Revolution she was suspected of sympathy for the king. She was forced to model heads of the revolutionary leaders, and of victims of the guillotine. She was later imprisoned. When released, she moved to London.

Tussock moth makes up a family whose caterpillars have *tussocks* (tufts) of hair along the back. These hair tufts are often brightly coloured. The caterpillars may also have distinct stripes on the back. The adult moths develop only dull colours.

The *gypsy moth* and *brown-tail moth* are European moths that have been introduced to North America. Their caterpillars have done much damage to trees in the New England states of the United States. They cause extensive damage by eating the leaves from broadleaf trees. The caterpillars often destroy whole orchards and forests. One method of control has been to import beetles that eat the caterpillars.

The *larvae,* or caterpillars, of the tussock moth eat the leaves of trees and can destroy entire forests.

Scientific classification. Tussock moths make up the family Lymantriidae. The gypsy moth is *Lymantria dispar.* The brown-tail moth is *Euproctis chrysorrhea.*

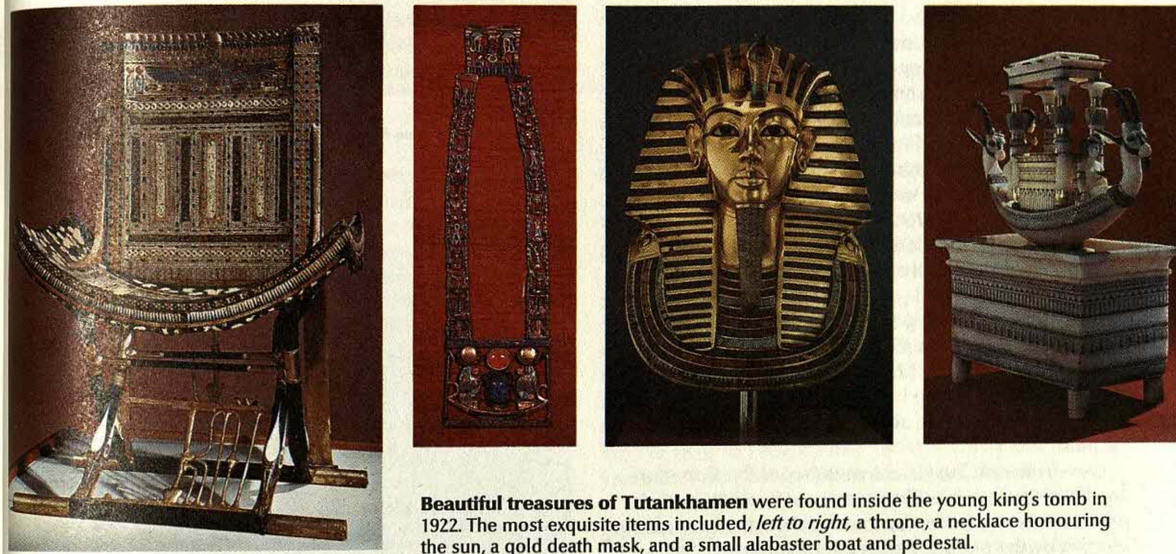
See also **Brown-tail moth; Gypsy moth; Moth** (Tussock moths; illustrations).

Tutankhamen served as king of Egypt from about 1347 B.C. until his death in 1339 B.C. His name is also spelled *Tutankhamun* or *Tutankhamon.* His reign was unimportant. But interest in Tutankhamen began in 1922, when the British archaeologist Howard Carter discovered his tomb. The tomb had not been opened since ancient times and still contained most of its treasures. It is the only tomb of an ancient Egyptian king to be discovered almost completely undamaged. See **Carter, Howard.**

Tutankhamen became king at about the age of 9. He probably received much assistance from Ay, his *vizier* (minister of state). Scholars disagree on who Tutankhamen's relatives were. Some believe the king was a son-in-law of King Akhenaton. Others think Tutankhamen was the son of Akhenaton and the grandson of King Amenhotep III. Still others argue that Tutankhamen and Akhenaton were brothers. Tutankhamen's original name was *Tutankhaton,* meaning *the living image of Aton* or *the life of Aton is pleasing.*

Akhenaton had made Aton the sole god of Egypt. He wanted Egyptians to stop worshipping the chief sun god Amon and other traditional gods. But, many Egyptians, including the powerful priests devoted to Amon, rejected the worship of Aton. Thus, about four years after he became king, Tutankhaton took the name Tutankhamen and restored Egypt's old religion. See **Akhenaton.**

Historians believe Tutankhamen died at about the age of 18, but they are unsure about the cause of his death. His funeral was held in the Valley of the Kings, a burial centre at Thebes. Ay succeeded Tutankhamen as king. Horemheb, a leading general, later succeeded Ay as king. Horemheb and his successors destroyed or removed all monuments that had been built by or in hon-



Beautiful treasures of Tutankhamen were found inside the young king's tomb in 1922. The most exquisite items included, *left to right,* a throne, a necklace honouring the sun, a gold death mask, and a small alabaster boat and pedestal.

our of Tutankhamen and others who had accepted Aton as Egypt's chief god. Partly because of these actions, little was known about Tutankhamen until Carter's discovery.

Carter searched for Tutankhamen's tomb for about 10 years. He finally discovered that its entrance had been hidden by debris from digging at the entrance of the nearby tomb of King Ramses VI. Tutankhamen's four-room tomb contained more than 5,000 objects, including many beautiful carved and gold-covered items. A magnificent lifelike gold mask of Tutankhamen covered the head and shoulders of the royal mummy.

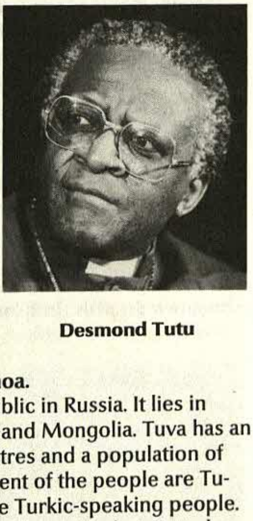
Among the items discovered were luxurious chests, thrones, beds, linens, clothing, necklaces, bracelets, rings, and earrings. Carter also found chariots, bows and arrows, swords, daggers, shields, ostrich feather fans, trumpets, statues of Tutankhamen and many Egyptian gods, figures of animals, models of ships, toys, games, and storage jars containing precious oils. The ancient Egyptians believed in a life after death, called the *afterlife.* They had their favourite possessions and practical objects buried with them for later use in the afterlife. Most of the items found in Tutankhamen's tomb are now displayed in the Egyptian Museum in Cairo.

One of the most informative items in the tomb was a note on the handle of the king's fan. The note indicated that the young Tutankhamen hunted at Heliopolis, near modern Cairo. Wine-jar labels indicated the length of Tutankhamen's reign. Several objects included scenes that show Tutankhamen slaying foreign enemies in battle. But scholars doubt that these scenes picture actual events.

Tutu, Desmond (1931-   ), is a South African civil rights leader and Anglican archbishop. He worked to end South Africa's strict racial segregation policy, known as *apartheid.* To help end apartheid, Tutu asked foreign nations and businesses to limit trade and investment activities in South Africa. In 1991, the South African government repealed the last of the laws that formed the legal basis of apartheid (see **South Africa** [History: Recent developments]).

Tutu won the 1984 Nobel Peace Prize for his nonviolent campaign against apartheid. In 1986, he became the first black to be elected archbishop of Cape Town. As archbishop of Cape Town, Tutu heads the Anglican Church in South Africa, Namibia, Mozambique, Swaziland, and Lesotho.

Tutu was born in Klerksdorp. In 1961, he was ordained an Anglican priest. In the mid-1960's, he received degrees in divinity and theology from King's College in London. He worked as an educator in the early 1970's. Tutu was named Anglican dean of Johannesburg, South Africa, in 1975. Tutu became bishop of Lesotho in 1976. He was named bishop of Johannesburg in 1984.



Desmond Tutu

Tutuila. See **American Samoa.**

Tuva is an autonomous republic in Russia. It lies in central Asia, between Siberia and Mongolia. Tuva has an area of 170,500 square kilometres and a population of about 276,000. About 60 per cent of the people are Tuvinians, whose ancestors were Turkic-speaking people. Most of them raise cattle and other animals. Minerals produced in the republic include asbestos and cobalt. The chief exports of Tuva are wool and animal hides. Kyzyl is Tuva's capital.

The region was part of Outer Mongolia (now Mongolia) until 1911. It then became independent, but Russia and China had strong influence there. It became a Russian protectorate in 1914. In 1921, it became the independent nation of Tannu Tuva. The name was later changed to Tuva. The Soviet Union, under Russia's leadership, annexed Tuva in 1944. Tuva became an autonomous republic within the Soviet republic of Russia. The Soviet Union was dissolved in 1991, but Tuva remained part of Russia.

Tuvalu is a small island country in the South Pacific Ocean. It has a population of 9,000 and a land area of 26 square kilometres. Among the countries of the world, Tuvalu has one of the smallest populations, and only Vatican City, Monaco, and Nauru are smaller in area. Tuvalu lies about 3,200 kilometres northeast of Australia. It consists of nine islands in a chain that extends about 580 kilometres. People live on eight of the islands. The country's name means *eight standing together.*

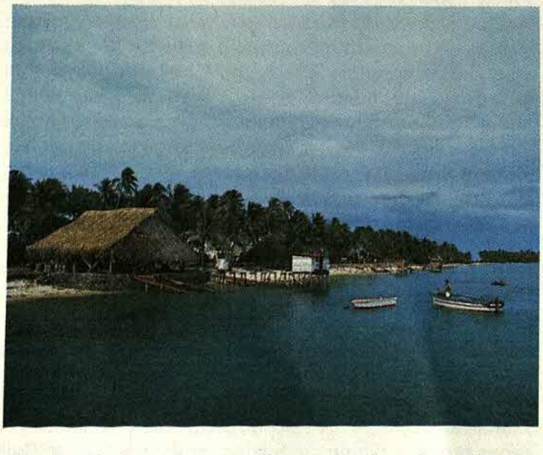
Tuvalu, formerly called the Ellice Islands, was ruled by Great Britain from the 1890's to 1978. It became independent in 1978.

Funafuti, an *atoll* (ring-shaped coral reef) with a population of about 2,800, is the capital of Tuvalu. The country's national anthem is "Tuvalu mo te Atua" ("Tuvalu for God"). Its unit of money is the Australian dollar. For a picture of Tuvalu's flag, see **Flag** (Flags of Asia and the Pacific).

Government. Tuvalu is a member of the Commonwealth of Nations (see **Commonwealth of Nations**). A prime minister, chosen by a parliament of 12 members elected by the people, heads the government. Local governments include seven island councils and the Town Council at Funafuti. The island councils have six elected members and up to four additional members appointed by various groups. Communities help control the government through gatherings in communal meeting houses called *maneapa.* Island courts handle most trials. The High Court of Tuvalu hears appeals.

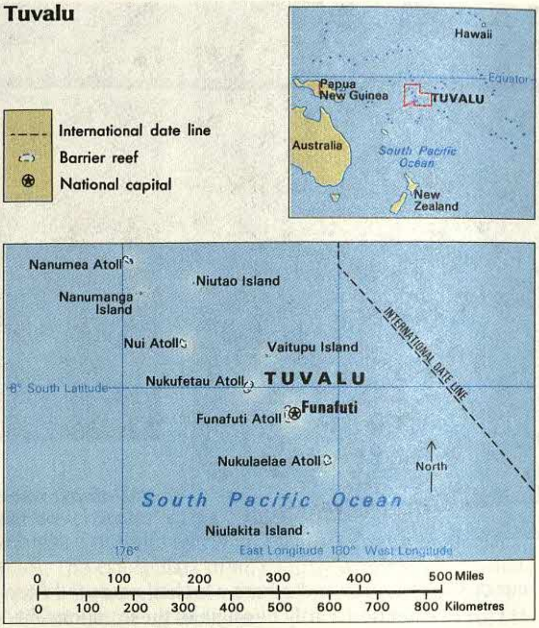
People. Most of the people of Tuvalu are Polynesians. Most live in villages built around a church and a meeting house. Tuvaluan houses have raised foundations, open sides, and thatched roofs. However, houses made of cement blocks and iron roofing are becoming more common. The main foods of the people are bananas, coconuts, fish, and *taro,* a tropical plant with one or more edible underground stems called *tubers.* The islanders also raise pigs and chickens, which they eat at feasts. Tuvaluans usually wear light, bright-coloured cotton clothing.

The people speak the Tuvaluan language, and many also know English. Both languages are used in official government business. Each of the eight inhabited islands has at least one primary school supported by the government. There are only two secondary schools in Tuvalu. A few Tuvaluans attend the University of the South Pacific in Fiji, which is an island country to the south.



The capital of Tuvalu is the village of Funafuti, *above.* The village is located on the island of Funafuti, which is one of the nine South Pacific islands that make up the country.

Tuvalu



Land and climate. The nine islands of Tuvalu are, from north to south, Nanumea, Niutao, Nanumanga, Nui, Vaitupu, Nukufetau, Funafuti, Nukulaelae, and Niulakita. Niulakita is uninhabited. Most of the islands are atolls that surround lagoons. The principal trees of Tuvalu are coconut palms and pandanus palms.

Tuvalu has a tropical climate, with daytime temperatures of about 27 °C. The southern islands receive about 356 centimetres of rain a year. The northern islands are drier.

Economy. Tuvalu is one of the least developed countries. It has poor soil, few natural resources, almost no manufacturing, and no mining. The people grow such crops as bananas and taro for their own use. Coconut palm trees cover much of the country, and the islanders use the coconuts to produce *copra* (dried coconut meat), their chief export (see **Copra**). Fees charged to foreign vessels fishing for tuna in the waters around Tuvalu are becoming another important source of income. Tuvalu women weave baskets, fans, and mats for export. Many young islanders work on ocean ships because of a lack of employment opportunities at home. Countries that provide aid to Tuvalu include Australia, Great Britain, Japan, and New Zealand.

History. The first inhabitants of Tuvalu probably came from Samoa hundreds of years ago. In 1568, Álvaro de Mendaña, a Spanish explorer, became the first European to see part of Tuvalu. But the islands remained largely unknown to Europeans until the early 1800's. Europeans called them the Ellice Islands. Great Britain took control of the islands in the 1890's. In 1916, Britain combined the islands with the Gilbert Islands to the north to form the Gilbert and Ellice Islands Colony. In 1975, the two island groups were separated. The Ellice Islands were renamed Tuvalu. Great Britain granted Tuvalu independence on Oct. 1, 1978.

See also **Funafuti; Gilbert Islands.**

TV. See **Television.**

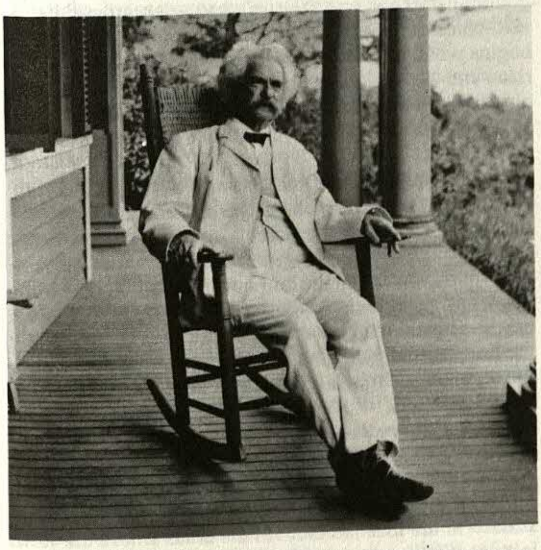
Twain, Mark (1835-1910), was the pen name of Samuel Langhorne Clemens, one of the major authors of American fiction. Twain is also considered by many to be the greatest humorist in American literature. Twain's varied works include novels, travel narratives, short stories, sketches, and essays. His writings about the Mississippi River, such as *The Adventures of Tom Sawyer, Life on the Mississippi,* and *Adventures of Huckleberry Finn,* have been especially popular.

Early life. Twain spent his boyhood years in Hannibal, a village on the Mississippi. There, he experienced the excitement of the colourful steamboats that docked at the town wharf, bringing comedians, singers, gamblers, swindlers, slave dealers, and an assortment of other river travellers.

With little formal education, Twain went to work in a print shop at the age of 12. He left Hannibal in 1853, and after working in print shops in various parts of the country, he eventually became a riverboat pilot on the Mississippi. His piloting experiences at this time allowed him to observe the many kinds of people who travelled aboard the steamboats. He later said of this period, "In that brief, sharp schooling, I got personally and familiarly acquainted with about all the different types of human nature that are to be found in fiction, biography, or history."

The outbreak of the American Civil War (1861-1865) put an end to his piloting, and Twain turned to newspaper journalism in the western United States. In 1863, he first used his pen name of Mark Twain—a riverboat term meaning *two fathoms* (a depth of 3.7 metres).

Success and fame. In 1867, Twain travelled to Europe and the Holy Land. This voyage yielded *The Innocents Abroad* (1869), in which the author ridiculed both American tourists and their hosts. After marriage in 1870, Twain and his wife settled in Hartford, Connecticut. During 20 years there, Twain wrote most of his best works. Among these were *The Adventures of Tom Sawyer* (1876), and his masterpiece, *Adventures of Huckleberry Finn* (1884), which describes the adventures of two runaways, the boy, Huck Finn, and the black slave, Jim. His satirical work, *A Connecticut Yankee in the Court of King Arthur* was published in 1869.



Mark Twain was a great American humorist. A white linen suit and a cigar became his trademarks in public appearances.

Later years. In the 1880's, Mark Twain established and operated his own publishing house. But he soon began to lose money and, in 1894, was declared bankrupt. But he continued to write, and undertook lecture tours in various parts of the world in order to recoup his losses. He returned to the United States an international hero. But then tragedy struck. His oldest daughter, Susy, died in 1896. In 1904, he lost his wife, Olivia and five years later his youngest daughter, Jean, also died.

Twain continued to write, but his works became gloomier, reflecting his doubts about religion and the destiny of man. On April 21, 1910, Twain died of heart disease, leaving behind many unpublished manuscripts.

Modern reputation. Since the 1960's, some people have come to view Mark Twain's life and outlook as gloomy and even tragic. Most people now consider him more than just a colourful, comic figure. Twain remains best known as a humorist, and his realistic prose style has influenced many writers. Ernest Hemingway aptly summed it up when he said that "all modern American literature comes from . . . *Huckleberry Finn.*"

Tweed is a rough, heavy, hairy, woollen cloth that may contain synthetic fibres. Tweed is usually woven of fibres in two or more colours. Some tweed has a plain weave. Other tweed has a *twill* weave, with raised diagonal lines. A third way of weaving tweed is with the diagonal raised lines of yarn meeting each other to form "V's." This is called *herringbone twill.* In Scotland, where tweed was first woven, *twill* is often pronounced *tweel,* and *tweed* may have developed from this. Some people believe the cloth was named after the River Tweed. Genuine Harris Tweeds are made by hand. They are woven on the islands of the Outer Hebrides—chiefly on Lewis with Harris Island.

The yarns are dyed the colours of the heather in the Hebrides. The dyes are made from a type of vegetation called *lichens,* which grow on the rocks of the islands. The lichen has an odour, called *cretal smell,* which never leaves the cloth. Rainy weather brings out this smell in a Harris Tweed suit. After the yarn is dyed, the longwise, or *warp,* threads are put on the looms. When the cloth is woven, the weavers have a ceremony called *waulking,* which means *shrinking.* The cloth is soaked in soapy water. The weavers stand around a table and pass the cloth while singing *waulking songs.* Each weaver pounds and rubs the cloth. The cloth is then washed and dried and is ready to be made into clothing.

Tweed is a favourite cloth for sports clothing, and coats and suits. Some tweeds are made in the United States, but they are usually lighter in weight and softer in texture than the cloth made in Scotland and England.

Tweed, River, rises in Scotland's Southern Uplands at Tweed's Well, about 10 kilometres northwest of the tourist centre of Moffat. It is about 154 kilometres long, and drains an area of about 4,800 square kilometres. In its early course, the Tweed flows northeastward to Peebles, and then eastward past Innerleithen. It approaches Galashiels and then flows past Kelso. The river forms the border between England and Scotland for about 27 kilometres, from shortly before Coldstream to near Berwick-upon-Tweed. At Berwick-upon-Tweed it empties into the North Sea (see **United Kingdom** [political map]). The much disputed border town of Berwick-upon-Tweed, which stands on the north bank of the river, became permanently part of England in 1885. The Tweed is navigable for only a few kilometres in its tidal section near its mouth. Salmon and trout are fished along the river.

Other small towns, such as Melrose, lie along the banks of the River Tweed. During the 1800's, these towns built mills along the river to provide water power for their cloth and hosiery industries. *Tweed,* the rough-textured woollen cloth from which warm suits, skirts, and other garments are made, may have been named after the river.

Magnificent abbeys, including Dryburgh Abbey and those at Melrose and Kelso, hint at the wealth and prosperity of these border lands watered by the river, and how much they were fought over in their turbulent history. Abbotsford House, the estate of the Scottish novelist Sir Walter Scott, is near Melrose.

Major tributaries of the Tweed include Ettrick Water, Gala Water, Leader Water, the River Teviot, and Whiteadder Water.

Tweeddale (pop. 15,314) is a local government district in Borders Region of the United Kingdom. It occupies the area of the former Scottish county of Peeblesshire, which ceased to exist in 1975. Tweeddale was the area's original name. The River Tweed rises in this hilly district. The making of tweed cloth and knitwear are important local industries, and wool is a major product of local farms. Forestry and tourism are other major industries. Peebles has become a major conference centre. See also **Borders Region.**

Tweedsmuir, Baron. See **Buchan, John.**

Twelfth Night is a Christian holiday celebrated 12 days after Christmas, on January 6. It marks the end of the Christmas season. Christians also observe the Feast of Epiphany on January 6 (see **Epiphany**). In Western Christian churches, this holiday commemorates the coming of the wise men to the Christ child. Among Eastern Christians, Twelfth Night celebrates the baptism of Jesus. In Italy and Spain, children still receive gifts on this day in remembrance of the gifts the wise men brought to Jesus. In the Greek Orthodox Church, the Blessing of the Waters takes place on January 6. In the ceremony, divers retrieve a cross thrown into a body of water by a priest. Twelfth Night was originally celebrated in the Middle Ages at the end of the 12 days of Christmas. William Shakespeare's comedy *Twelfth Night* was possibly first performed on January 6.

Twelve Tables, Laws of the, were the first written laws of the Romans. The laws were inscribed on 12 tables, or tablets, that were fastened to the speaker's stand in the Roman Forum. They were the basis of private rights of Roman citizens. They dealt with legal procedures, property ownership, building codes, punishments for crime, and marriage customs.

The laws were drawn up in 451 and 450 B.C. by *decemvirs* (members of a council of ten men). The decemvirs based the laws on earlier Roman civil, criminal, and religious customs. The laws applied equally to all Roman citizens, and were written out so that the common people could know their legal rights. The original tables bearing the laws were destroyed about 390 B.C. But large parts of the laws are preserved in the works of Roman writers who, like all Roman boys, had learned them by heart.

Twelve Tribes. See **Jacob; Jews** (Early days); **Palestine** (Early history and Hebrew settlement; map).

Twenty-eight is the name of an Australian parrot whose ringing call sounds as though it is saying "twenty-eight." The parrots are greenish in colour. They have a yellow neck and a dark head that has a red patch on the forehead. The birds are found only in the southern corner of Western Australia. Other subspecies are found in other parts of Australia, and have the general name of Port Lincoln parrots.

Scientific classification. The twenty-eight parrot belongs to the family Psittacidae. It is *Barnardius zonarius.*

Twenty-sixth of July Movement was a Cuban revolutionary group led by Fidel Castro that overthrew the dictator Fulgencio Batista in 1959. The movement was named after the date in 1953 when Castro led an unsuccessful attack on an army barracks in Santiago de Cuba. Castro formed the movement in 1955. He then went to Mexico to train the group in guerrilla warfare. The guerrillas returned to Cuba in December 1956 and based their activities in the Sierra Maestra mountains. Popular support for Castro grew during 1957 and 1958, and the 26th of July Movement joined forces with other opposition groups. Batista was forced to leave the country on Jan. 1, 1959, and Castro became the country's ruler. See also **Castro, Fidel; Cuba** (History: The Castro revolution).

Twickenham. See **Richmond upon Thames.**

Twilight is the period just before sunrise and the period just after sunset when the light in the sky is soft and mellow. Although the sun is below the horizon, the sky is illuminated because the sun's rays are scattered by molecules of the earth's atmosphere. Morning twilight begins when the sun is about 18 degrees below the horizon and ends when the sun reaches the horizon. Evening twilight begins when the sun drops below the horizon and ends when it has sunk about 18 degrees below the horizon.

Twilight lasts the longest time at the North and South poles and the shortest time at the equator. During the six sunless months at the poles, dawn and dusk last a month each. But there is a period during Arctic and Antarctic summers when the sun never sinks below the horizon, and twilight does not occur. Just south of the Arctic, the summer sun never reaches 18 degrees below the horizon, and twilight lasts from sunset to sunrise. At the equator, twilight lasts about an hour, with some seasonal variations.

Twill is a weave that is used in making many kinds of strong, durable cloth. In twill, the lengthwise threads, known as *warp,* meet the crosswise threads, called *weft* or *filling,* in such a way that diagonal lines form on the surface of the finished cloth in the areas where the yarns interlace. These diagonal lines may slant to the left or the right. They may be raised a little or a great deal.

Many twill fabrics display an even number of warp and weft yarns on the surface, but some show more of one type than the other. Twill weaves can be varied to produce broken, entwining, figured, or reversing lines. Such materials as *serge, gabardine, denim*, and *cheviot* are twill-weave fabrics.

Twine is tough cord made from the twisted strands of hard leaf fibres, usually those from the sisal or henequen plants. The strands are mixed with abacá to make manila hemp. Twine is made by drawing the fibres into slivers, which are combed and spun into twine. String is a type of twine, thinner than a cord and thicker than a thread. See also **Abacá; Sisal.**

Twinflower, also called *Linnaea,* is a low-growing, evergreen, woody plant, named after the Swedish botanist Carl von Linné. It was his favourite among all wild flowers in Sweden. Twinflower is found in northern forests. It is a favourite plant in rock gardens with a rather acid, loose, moist soil. Twinflower grows only several centimetres high, but spreads over as much as 50 centimetres. It has long, woody stems and roundish leaves. Its delicate flowers are shaped like bells, and are pink or white. The flowers have a fragrant odour.

Scientific classification. The twinflower belongs to the honeysuckle family, Caprifoliaceae. It is *Linnaea borealis.*

See also **Flower** (Flowers of woodlands and forests [picture]).

Twins. See **Multiple birth; Siamese twins.**

Twins, The. See **Castor and Pollux.**

Two Sicilies, Kingdom of the. See **Sicilies, Kingdom of the Two.**

Two-stroke engine. See **Diesel engine; Petrol engine.**

Twofold Bay is a deepwater harbour and tourist resort on the far south coast of New South Wales, Australia, about 50 kilometres north of the Victorian border. The town of Eden is situated on a headland overlooking Twofold Bay. The town is the headquarters of a large fishing fleet. It is an oil port, and also serves as a timber port. Eden's fish cannery at Snug Cove is the largest in Australia. It processes tuna, salmon, abalone, and mullet. A bulk oil terminal is also located at Snug Cove. A chip mill in the district exports wood chips to Japan.

Boydtown was established by merchant-adventurer Benjamin Boyd about 11 kilometres from Eden on the southern shore of Twofold Bay. It was the centre of a colonial whale fishery throughout the 1800's. Some of the relics of the partially completed Boydtown are the inn, and the ruins of the church and a lighthouse tower, neither of which was ever used.

See also **Boyd, Ben; New South Wales** (History); **Whaling.**

Tyburn Tree was the popular name for the gallows that occupied a site close to what is now Marble Arch, in London, from the 1100's until the late 1700's. The first recorded hanging at Tyburn took place in 1196. A series of wooden gallows were used until 1571, when a permanent gallows was erected.

Among those hanged on Tyburn Tree were Perkin Warbeck, a pretender to the throne of England (1499), and Edmund Campion, a Roman Catholic martyr (1581). In 1661, after the Restoration, Oliver Cromwell's body was exhumed, beheaded, and hung on a gibbet at Tyburn. Murderers and common criminals were also executed at Tyburn. These criminals included the notorious highwayman Jack Sheppard and the gang leader Jonathan Wild.

Tyche. See **Fortuna.**

Tyler, John (1790-1862), was president of the United States from 1841 to 1845. He was the first vice president to become president upon the death of a chief executive. On April 6, 1841, he succeeded President William Henry Harrison, who died a month after taking office. Tyler, a Southern Democrat, had split with his party and had run with Harrison for the Whig Party.

When Tyler joined the Whigs in 1840, he believed the party had dropped its fight for a national bank and protective tariffs. But after Tyler became president, the Whigs in Congress introduced a legislative programme that included calls for both. Tyler vetoed those measures and almost every other important bill they passed. Angry Whigs tried to impeach him, but they failed. Tyler was born at Greenway estate in Charles City County, Virginia, U.S.A. He was elected vice president of the United States in 1840.

See also **United States, Government of the.**

Tyler, Wat. See **Wat Tyler's Rebellion.**

Tylor, Sir Edward Burnett (1832-1917), a British anthropologist, is often regarded as the father of anthropology in the English-speaking world. His books stimulated the development of this science. Tylor was born in London. He travelled widely. Although he never studied formally at a university, he was professor of anthropology at Oxford from 1896 to 1909. He wrote *Researches into the Early History of Mankind* (1865) and *Primitive Culture* (1871). See also **Culture** (Characteristics of culture); **Mythology** (How myths began); **Religion** (The origin of religion).

Tyndale, William (1494-1536), was an early English leader of the Reformation. He is best known for translating the Bible from Greek and Hebrew into English. His work later became important as a basis for the Authorized Version of the Bible.

Tyndale first translated the New Testament in an effort to make the Scriptures more widely available, but he could not get it published in England. After leaving England permanently in 1524, he finally had his translation published in Germany and had copies smuggled into England. See **Bible** (Early English translations).

Tyndale was born in Gloucestershire, England. He studied at Oxford and Cambridge universities from 1510 to about 1521 and was ordained a priest. He was strongly influenced by the ideas of his friend, the German Reformation leader Martin Luther. Tyndale was executed by Roman Catholic authorities as a Protestant heretic in Belgium.

Tyndall, John (1820-1893), was a British physicist and natural philosopher. He is best known for his experiments on the scattering of light of different colours by small particles. The bluish appearance of a light beam passing through something like a soap solution is called the *Tyndall effect.* Tyndall was also interested in the biological sciences. In 1876, he described the action of a *Penicillium* mould in slowing the growth of bacteria. This was more than 50 years before Sir Alexander Fleming's chemical work on penicillin. Tyndall was born in Leighlin Bridge, Ireland. He became director of the Royal Institution, London, in 1867. Tyndall wrote about his former colleague there, Michael Faraday, in his book *Faraday as a Discoverer* (1868).

Tyne is a river in northeastern England. It begins where the North Tyne and the South Tyne merge, west of Hexham in Northumberland. From there, it flows 48 kilometres eastward into the North Sea. The Tyne can accommodate ocean-going ships as far as Newcastle upon Tyne. Both banks of the river, from Newcastle to the sea, are lined with docks and industrial works. This great industrial centre is known as *Tyneside.*

Tyne and Wear is a county in northeastern England. It takes its name from two rivers that flow through the county and empty into the North Sea.

Tyne and Wear was created as a *metropolitan county* in 1974. Previously, the area had formed the southern part of the county of Northumberland and the northern part of County Durham. In 1986, the metropolitan county council was abolished and most of its powers transferred to the metropolitan districts within the county.

The people who live in the Tyneside area, which makes up most of the county, are called *Geordies.* The term *Geordie* originally referred to a coal miner, to the miner's safety lamp, or to the boats that carried coal.

People and government

Local customs. Newcastle Town Moor Fair, also called the *hoppings,* is traditionally held in Race Week, the last week in June.

Folk music and dance are an important feature of life in Tyne and Wear. Some local songs are well-known nationally, including "The Keel Row" and "The Water of Tyne." Another such song, "Blaydon Races," was first sung in 1862 by Geordy Ridley, a miner from Gateshead. The most popular of local dances are the clog dances of mining villages and *rapper* (sword) dances.

Recreation. Soccer is the most popular sport. Newcastle and Sunderland have teams that play in the Football League. Recently, rugby has grown in popularity in schools. League cricket is played in summer.

Local government. The county has five metropolitan districts that are responsible for such services as education, housing, libraries, and social welfare in their own areas. The districts are *Gateshead,* which also includes Birtley; *Newcastle upon Tyne,* which also includes Gosforth; *North Tyneside,* which includes North Shields and Wallsend; *South Tyneside,* which includes Hebburn, Jarrow, and South Shields; and *Sunderland,* which also includes Washington. Washington became a *new town,* in 1967. The crown court meets in Newcastle. The Northumbria Police serve Tyne and Wear.

Economy

Manufacturing. The area was one of Britain's earliest industrial centres. Traditional local industries are chemicals manufacture, heavy engineering, and shipbuilding. Since World War II (1939-1945), the area has attracted new light industries and the manufacture of home appliances. From the mid-1950's onwards, the area had much unemployment because of a decline in coal mining and shipbuilding. The national government gave aid to reduce the area's unemployment. This aid included sponsoring industrial estates with a variety of factories. There are estates at Gateshead, Jarrow, North Shields, and Sunderland. In 1987, the Tyne and Wear Development Corporation was established to help the economic and urban regeneration of Tyneside.

The River Tyne and River Wear were leading sites for shipbuilding for many years. After World War II, local shipbuilders specialized in building oil tankers and bulk carriers. In the 1970's and 1980's, the industry declined and closed down. Construction work for the offshore oil industry partly replaced it. Engineering industries in the county are varied. Typical products are cranes, machine tools, and pumps. Heaton in Newcastle has heavy electrical engineering works. Hebburn workers make switchgear machinery.

Mining. Coal mining previously played a large part in the economy of Tyne and Wear. However, many pits have closed since the 1950's. There are still a few mines south of the River Tyne.

Agriculture is limited in Tyne and Wear. Little land is available for farming, because most of the area is built on, derelict, or liable to subside because of coal mining underneath. There is some small-scale dairy farming and some market gardening.

Transportation and communication. The A1(M) motorway leads from the south to Newcastle. Newcastle has a partial minor motorway system. Among the bridges that cross the Tyne in central Newcastle are the High Level Bridge, a road and rail bridge designed by George Stephenson, which opened in 1849; the Swing Bridge, built in 1876; and the Tyne Bridge, built in 1928. Road traffic also uses the Tyne Tunnel between Jarrow and Howdon, completed in 1967. In central Sunderland, two road bridges cross the Wear—the Queen Alexandra Bridge (1903) and the Wearmouth Bridge (1929).

A rapid-transit rail system was constructed in the Tyneside area in the early 1980's. It has an underground section beneath Newcastle. The main east coast line of British Rail connects Newcastle with London to the south and Edinburgh to the north.

The Tyneside docks of Port of Tyne import foodstuffs, petroleum products, and timber. Exports include coal and manufactured goods. The port has a passenger and car terminal for Norway. Sunderland's port deals mainly with British trade, importing petroleum products and exporting coal.

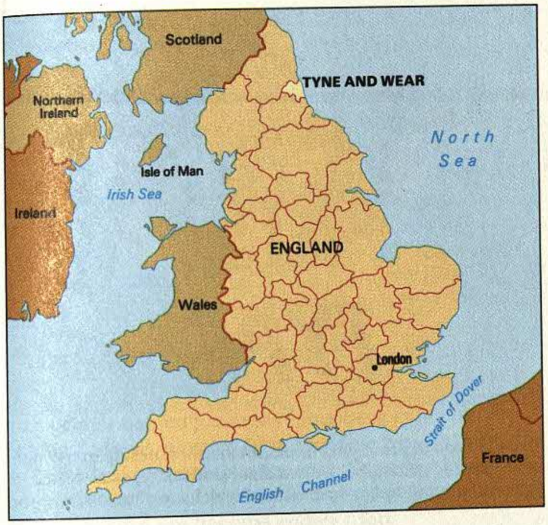
Both the British Broadcasting Corporation (BBC) and an independent company under the Independent Broadcasting Authority, Tyne Tees Television, have television studios in Newcastle. Newcastle also has BBC and independent local radio stations. Local daily newspapers are Newcastle's *The Journal* (morning) and *Evening Chronicle* and Sunderland's *Echo.*

Land

Location and size. Tyne and Wear is bounded in the north and west by Northumberland, and in the south by

Facts in brief about Tyne and Wear

Administrative centre: Newcastle upon Tyne.
Largest towns: Sunderland, Newcastle upon Tyne, South Shields, Gateshead.
Area: 540 km².
Population: *1991 census*—1,087,000.
Chief products: *Manufacturing*—cars, chemicals, cranes, domestic appliances, electrical engineering, machine tools, ships.



Tyne and Wear is in northeast England on the North Sea coast. Two rivers, the Tyne and the Wear, flow through the county.

Durham. In the east, it is bounded by the North Sea. The county's maximum distance is 30 kilometres from north to south and 32 kilometres from east to west.

Land features and rivers. Tyne and Wear is a low-lying county. Newcastle lies on a low sandstone and shale plateau cut by the gorge of the River Tyne. Sunderland and South Shields lie on a limestone plateau, cut by the Wear gorge at Sunderland.

Climate is typical of England's east coast, but drier and cooler in the summer than areas further south. Breezes blow almost constantly, but, in the spring and summer, a chilly coastal fog, called *haar,* is quite common. Snowfall is low, and snow rarely lies more than a few days. Average annual rainfall is about 700 millimetres. Average temperatures are about 4° C in midwinter and about 15° C in midsummer.

History

Hadrian's Wall, built by the Romans in the A.D. 120's and 130's, started at Wallsend, at that time called *Segedunum.* Newcastle, at that time called *Pons Aelius,* was a bridging point, and South Shields was a fort and signal station. The Angles invaded the area in the 400's. Christianity spread to the area from Lindisfarne in the 600's. Monasteries were established at Jarrow and Monkwearmouth in Sunderland.

In the late 1000's, the Normans built the new castle that gave Newcastle its name. Town walls were built in the 1300's. The wool trade developed and city guilds were created. Records show that shipbuilding at Sunderland had started by the 1340's. The coal trade grew rapidly on the rivers Tyne and Wear during the 1400's. In the 1600's, wooden wagonways were laid from the mines to the docks. By 1700, Tyne and Wear had factories producing chemicals, coal, glass, salt, and ships.

In 1850, Sunderland's port was extended and an improvement commission was established for the Tyne. Between 1850 and 1914, the towns in Tyne and Wear spread. World War I (1914-1918) was followed by economic depression, causing much unemployment. Since 1934, government policies have helped reduce unemployment, but the recession of the early 1980's hindered these efforts.

Famous people born in Tyne and Wear include the historian the Venerable Bede; the admiral Lord Collingwood; the railway engineer George Stephenson; and the maker and demonstrator of the first electric light bulb, Sir Joseph Swan.

Related articles in ***World Book*** include:

Bede
Collingwood, Lord
Gateshead
Hadrian's Wall
Industrial Revolution
Lindisfarne
Newcastle upon Tyne
Stephenson (family)
Sunderland
Swan, Sir Joseph Wilson

Tynedale (pop. 56,400) in Northumberland, England, is the largest local government district in England and Wales. It covers 2,220 square kilometres. It is bounded by Borders Region of Scotland and the English counties of Cumbria, Durham, and Tyne and Wear.

Tynedale is mainly rural and has some of the most beautiful scenery in Britain. Its chief towns are Haltwhistle; Hexham, which is the administrative centre; and Prudhoe. Tourism is a vital industry in Tynedale. Important historic sites include Hadrian's Wall and the Roman fort of Vindolanda. Several museums display Roman finds. Farmers grow arable crops in the valley areas and raise sheep and cattle in the hills. The chief industries include light engineering, printing, and the manufacture of aluminium components, chipboard, de-icing fluid, paints, and plastics. Sawmills operate at Hexham, while Prudhoe's workers produce dyestuffs, furniture, and paper tissue. *Fluorspar,* a mineral used for hardening steel, and coal are mined locally.

See also **Northumberland.**

Tynwald. See **Man, Isle of** (Government).

Type is a letter, number, or other character used in printing. The words and numbers in all printed materials, including books, magazines, and newspapers, are made from type. There are two chief kinds of type, *metal type* and *photographic type.*

Metal type, also called *hot metal type,* consists of pieces of metal that have raised letters on top. It is made by machines that force a mixture of molten lead, tin, and antimony into *matrices* (moulds) of each character.

Photographic type consists of photographic images of letters. It may be produced by several methods, all of which are called *photocomposition.* In one method, printers make a film negative that contains a *fount,* a set of all the characters of one style and size. A beam of light is projected through a character onto the negative, producing a photographic positive of that character. *Cathode-ray tube photocomposition* is another method of producing type. Detailed instructions for the shape of each character in a fount are stored in a computer. Using these instructions, a device called a cathode-ray tube projects beams of electrons that reproduce the character images onto a screen. The images are then focused through a lens onto photosensitive paper or film. See **Photocomposition.**

Another kind of type, called *dry transfer* or *rub-down type,* is often used to compose only a few words. Each character consists of a thin layer of hardened ink attached to a piece of waxed paper. The ink is simply rubbed onto another piece of paper.

Type is made in many sizes and thousands of styles. Each style of type, or *type face,* has its own characteristics that make it suitable for different purposes. Some styles of type have bold, heavy lines, and other type faces have a thin, graceful appearance.

Classes of type. There are three main classes of type styles: (1) serif, (2) sans-serif, and (3) display.

Serif types have small finishing strokes called *serifs* that extend from the main strokes of the letters. A serif type face normally has three versions: (1) the *roman* or upright form; (2) the *italic* or sloping form; and (3) the *bold* form, which is a heavier form that is usually available in both roman and italic. Popular serif type faces include Baskerville, Bodoni, Garamond, and Times.

Serif types include a few designs called *black letter* and a few called *uncial.* Black letter designs have highly decorative letters with thick, heavy lines. The first European printing types were black letter. Uncial designs are based on a letter style that was popular from the A.D. 300's to 700's. They were first produced in type in the 1900's. Most uncial letters look like rounded capitals. The first serif-style type similar to the ones used today was perfected about 1470 by a French printer named Nicolas Jenson.

Sans-serif types do not have serifs. *Sans* is a French word that means *without.* A sans-serif type face is normally available in roman, italic, and bold. Popular sans-serif type faces include Futura, Helvetica, and Univers. William Caslon IV, an English printer, made the first sans-serif type about 1816.

Display types are normally available only in larger sizes and are used for advertisements, headings, posters, and in other instances where a decorative or eye-catching type face is needed. This class of type includes *script* faces, which resemble handwriting. The *lower-case* (small) letters of many script styles are joined together.

Sizes of type. Printers in many countries, including Australia, Canada, Great Britain, and the United States, use a special scale to measure the size of type and the length of lines of type. This scale is called the *American Point System.* One *point* on the scale equals 0.3514598 millimetre. One inch (2.54 centimetres) equals about 72 points. Printers measure the length of a line of type in *picas.* One pica equals 12 points.

Type is used in producing books, magazines, newspapers, and other printed materials. The two chief kinds of type are metal type and photographic type, both of which are shown above.

The point size of type refers to the height of the characters. The height of the main part of a small letter is called the *x-height.* Such letters as *a, c, e,* and *x* have only an x-height, but others have strokes that extend above or below the x-height. Letters with *ascenders* include *b, d,* and *f.* Letters with *descenders* include *g, j,* and *p.* The point size of any type is the distance from the top of the ascenders to the bottom of the descenders. It may include a slight space above the ascenders or below the descenders.

Metal type ranges in size from 4-point to 120-point. However, most styles are not made in all sizes. The most common sizes include those from 6-point to 72-point. You are now reading 9-point type.

Most photographic type is made in only a few small sizes. A fount can be enlarged or reduced to other type sizes by lenses in the photographic equipment. In cathode-ray tube photocomposition, instructions for enlarging or reducing type size are stored in the computer.

In some European countries, including France, Germany, and Italy, type is measured by the *Didot point.* This point is slightly larger than the American point.

History. Until the 1400's, most books were produced by people who copied them by hand. About 1440, a Ger-

Classes of type Type is made in thousands of styles. These type styles are grouped into three general classes: serif, sans-serif, and display. A few styles of each class are shown below.

Serif

Give me liberty or give me death.
8-point Times Roman

Give me liberty or give me death.
9-point Garamond

Sans Serif

Give me liberty or give me death.
10-point Helvetica Light

Give me liberty or give me death.
11-point Univers Medium

Display

Give me liberty or give
14-point Aachen Bold Outline

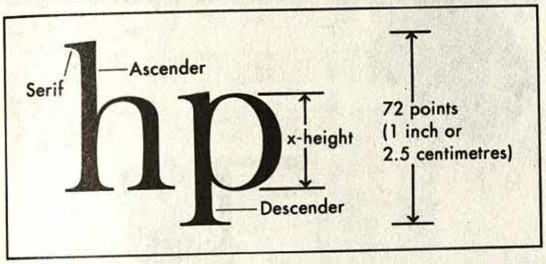
Give me liberty or give
14-point Benguiat Bold

Give me liberty or give
14-point Kabel Demi Outline Drop Shadow

Give me liberty or give me death
14-point Revue Condensed

Parts of letters

This diagram shows the main parts of lower-case letters. Printers measure the distance from the top of an *ascender* to the bottom of a *descender* to determine the point size of type.



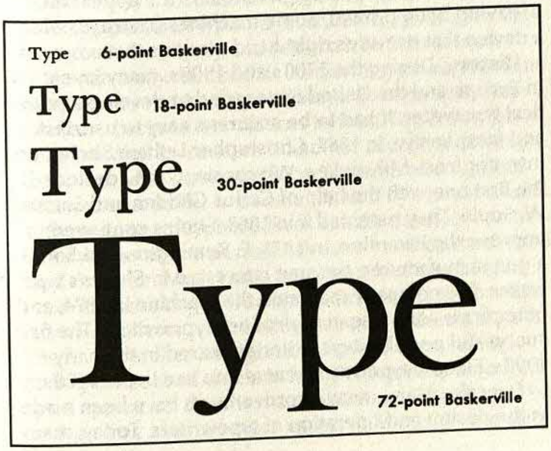
man printer named Johannes Gutenberg made the first practical use of *movable type.* Movable type consists of an individual piece of type for each character. It had been invented about 1045 by Bi Sheng, a Chinese printer, but did not become widely used.

For about 400 years, printers *set* (assembled) all type by hand. In the 1880's, Ottmar Mergenthaler, a German instrument maker, invented the *Linotype.* This machine assembled matrices from which whole lines of type were *cast* (moulded) as solid slugs. In 1887, an American inventor named Tolbert Lanston developed a machine called the *Monotype,* which cast individual pieces of type and set them into lines. Some printers still use the Linotype and Monotype machines. See **Linotype; Monotype.**

One of the first commercial machines to produce and set photographic type was invented in the 1940's. During the 1950's and 1960's, engineers developed new phototypesetting machines that set type much faster than the earlier kinds. These machines can be linked to computers that handle many tasks formerly performed by people. For example, the computers "tell" the machine how to *justify* (align) lines of type and hyphenate words. Other developments in typesetting include machines that reproduce type characters from computer instructions onto the screen of a cathode-ray tube.

Some type sizes

The most common sizes of type range from 6-point to 72-point. A few of the sizes within this range are shown below.


Type 6-point Baskerville
Type 18-point Baskerville
Type 30-point Baskerville
Type 72-point Baskerville

Computer-generated characters can also be sent direct to various kinds of printer in the form of electronic codes. The results range from low-quality characters with a noticeable "dotty" structure to high-quality print suitable for use in books.

Related articles in *World Book.* See the article on **Printing** for an explanation of how type is used in the printing process. See also the following articles:

Baskerville, John
Bodoni, Giambattista
Book (The development of printed books)
Electrotyping
Goudy, Frederic
Gutenberg, Johannes
Italics
Jenson, Nicolas
Stereotyping

Type metal. See **Alloy** (Other alloys).

Typesetting. See **Printing** (Typesetting).

Typewriter is a machine that produces printed letters and figures on paper. People in homes and offices throughout the world use typewriters to write rapidly and neatly. The typewriter ranks as the most widely used kind of business machine.

Kinds of typewriters. There are four basic kinds of typewriters: (1) manual, (2) electric, (3) electronic, and (4) text-editing, usually called *word-processing typewriters* or *word processors.* A manual typewriter operates entirely by the power supplied by the typist's hands. An electric typewriter has an electric motor to provide power, and so the typist only needs to touch the keys lightly. Such a typewriter costs more to buy and operate than a manual typewriter, but it is easier to use. It also enables a person to type faster and more neatly.

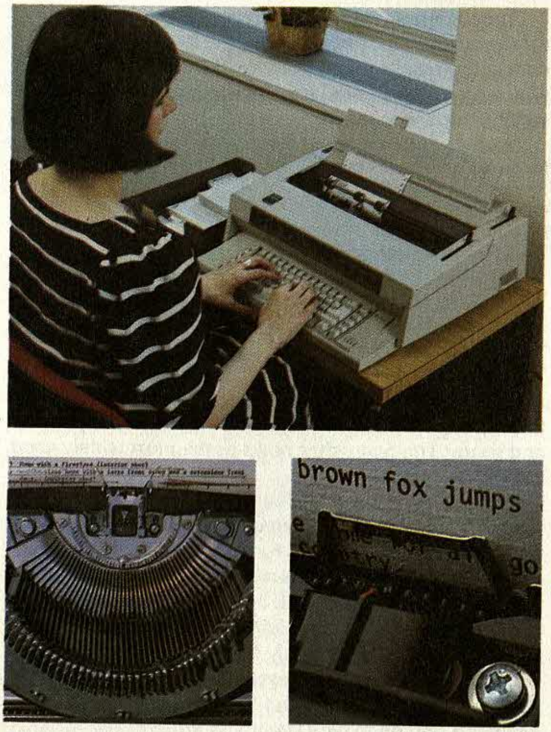
Some electric typewriters, called *self-correcting typewriters,* erase typing errors. Chemically treated correcting ribbons cause any incorrect figure to peel off when the typist presses a certain key. The typist then types the correct character in the space left blank.

Manufacturers make portable models of manual, electric, and electronic typewriters. The greater compactness and lighter weight of portable typewriters make them popular among students and travellers.

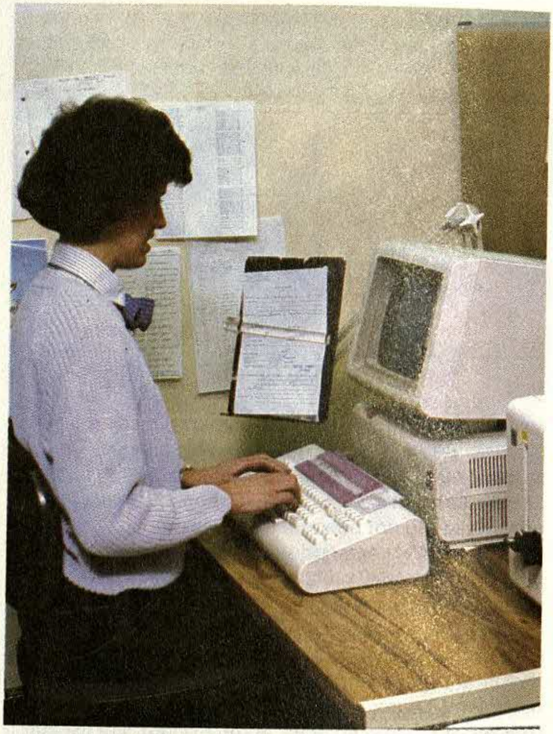
Electronic typewriters resemble electric typewriters but include a tiny computer called a *microprocessor.* The microprocessor enables the typewriter to automatically perform such functions as setting margins and underlining. Most microprocessors in electronic typewriters also have a *memory,* which can store names, dates, addresses, and other material that a typist frequently repeats. When the typist presses the appropriate key, the machine "recalls" the stored material and types it automatically. On some electronic typewriters, a *display screen* shows material as it is typed.

With word processors, the material the operator types is stored on a magnetic card, tape, or disc. The typist can make corrections by simply typing over an error. The typist can also add, delete, or move individual letters, words, lines, and paragraphs without retyping the entire document. After a document is typed and stored, the machine prints it out at the touch of a button. Some word-processing units print as many as eight pages per minute.

Most word processors have an electronic display screen. A microprocessor enables the machine to handle a variety of tasks. For example, most word processors can sort and merge lists, perform mathematical equations, and transfer information to other word processors and to computers over telephone lines.



A typewriter prints when a typist strikes a key, forcing a character against an inked ribbon onto paper, *above*. The characters on some typewriters are on levers, *lower left*. Many have the characters on the spokes of a *daisy wheel, lower right*.



A word processor is a machine that allows the typist to revise material quickly and easily without retyping the entire document. Most word processors have televisionlike *display screens*, which show the text as it is typed or edited.

Parts of a typewriter. Most manual, electric, and electronic typewriters have similar basic features. The machine has a keyboard that consists of buttons called *keys*. Each key carries two characters—letters, numbers, punctuation marks, or other symbols. A key forms one end of a lever that has a bar of metal type at the other end. When the typist strikes a key, the type bar rises and hits an inked ribbon or a thin strip of carbon tape. The ribbon or tape is in front of the paper, on which the type bar prints a letter or other character. A hard rubber roller called a *platen* holds the paper in the typewriter. The platen and paper automatically move one space to the left after the typist strikes a key.

Some typewriters do not have type bars. Instead, they have a ball-shaped *fount* or *typing element*, which contains a complete set of all the characters. When the typist strikes a key, the ball turns so that the correct character hits the paper. The ball moves along the line being typed, and the platen does not move. The type style or size can be changed by replacing the ball. Many electronic typewriters have a printing element called a *daisy wheel*. When the typist strikes a key, the daisy wheel spins until the appropriate character is in position.

A warning bell rings when the typist nears the end of a line. A lock prevents any typing past a particular point unless the typist presses the margin-release key. Most typewriters also have an automatic ribbon reverse, a backspace lever, and a *tabulator*, which enables the machine to line up numbers or words in columns.

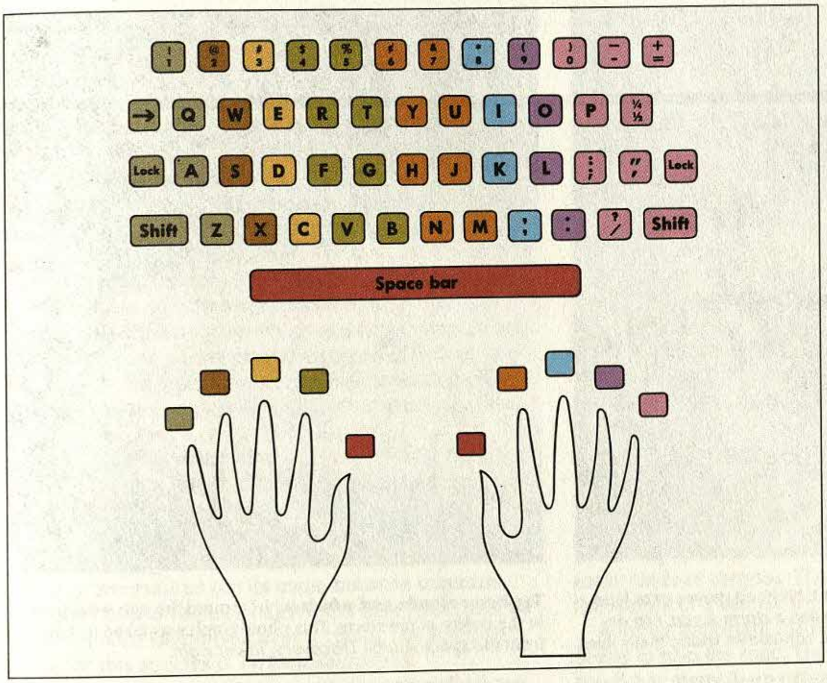
Typewriter manufacturers produce more than 5,000 kinds of keyboards and over 100 type styles. Some keyboards have the letters and symbols of various languages, and others feature special symbols, such as those used in music.

Some typewriters have large type for the partially sighted. Some typewriters for the blind are equipped with special devices that "speak" the characters as they are typed. Others type in braille.

On many typewriters, each letter or other character fills the same amount of space on the paper. But some typewriters feature *proportional spacing*, in which the space taken by each character varies according to its size. Proportional spacing gives letters the appearance of having been printed. Some machines have a *justifier*, a device that provides right-hand margins that are even.

History. During the 1700's and 1800's, many inventors in Europe and the United States tried to develop a practical typewriter. It had to be accurate, easy to use, fast, and inexpensive. In 1867, Christopher Latham Sholes, an inventor from Milwaukee, Wisconsin, U.S.A., designed the first one with the help of Carlos Glidden and Samuel W. Soulé. They patented it in 1868. Sholes continued to improve the invention. In 1873, E. Remington and Sons, a gun manufacturer, became interested in Sholes's typewriter. The company marketed the machine in 1874, and other firms soon began to produce typewriters. The first successful portable typewriter appeared in the early 1900's. Electric typewriters came into use in the 1920's.

Over the years, many improvements have been made in the design and operation of typewriters. Today, many



A typewriter keyboard has a standard arrangement of keys. The colours shown in this diagram indicate which finger is used to strike each key. Either thumb is used for the space bar.

people use personal computers with printers as word processors to produce high-quality typing.

See also **Edison, Thomas A.** (The Wizard of Menlo Park); **Glidden, Carlos; Sholes, Christopher L.; Teletypesetter.**

Typhoid fever is a serious bacterial disease that results in fever, weakness, and, in severe cases, death. It was once common in all heavily populated regions. However, as methods of good hygiene and sanitation were developed, typhoid fever occurred less often. It is now relatively rare in areas that have modern standards of sanitation.

Cause and spread. Typhoid fever is caused by a bacterium called *Salmonella typhi* (abbreviated *S. typhi*). This organism passes indirectly from one person to another, chiefly through contaminated water or food. Victims of typhoid fever shed *S. typhi* in their *faeces* (solid body wastes) and urine. Apparently healthy persons, called *carriers,* also spread the bacteria. Carriers do not have symptoms of typhoid fever, but they harbour the bacteria in their body and release it in their faeces.

Human body wastes that contain *S. typhi* can contaminate food or water in several ways. For example, flies can carry bacteria from faeces to food. Food that has been handled by carriers is another source of infection. In regions with poor sanitation, bacteria often spread after water supplies are contaminated by human wastes.

Symptoms of typhoid fever usually develop one to three weeks after a person has consumed contaminated food or water. Most cases last about four weeks after the symptoms begin. During the first week, the person has a rising fever, with headaches and abdominal pain. The fever reaches its highest point and remains high during the second week. In many cases, rose-coloured spots appear on the chest and abdomen. The person becomes weak and, in severe cases, delirious. By the start of the third week, a greenish, soupy diarrhoea develops in most cases. The disease reaches its height at this point. Unless complications occur, the person gradually improves during the end of the third week and during the fourth week.

Serious, sometimes fatal, complications can develop. The bacteria may produce *ulcers* (open sores) in the intestine. If the ulcers become severe, they can make holes in the intestinal wall. In such cases, the contents of the intestines spill into the abdomen, and serious abdominal infections can follow. In other instances, the intestines may bleed severely. Blood transfusions may be necessary to prevent death.

Treatment and prevention. Doctors use antibiotic drugs to treat typhoid fever (see **Antibiotic**). These drugs check the growth of *S. typhi* and speed recovery. The use of antibiotics greatly reduces the risk of dying from typhoid fever.

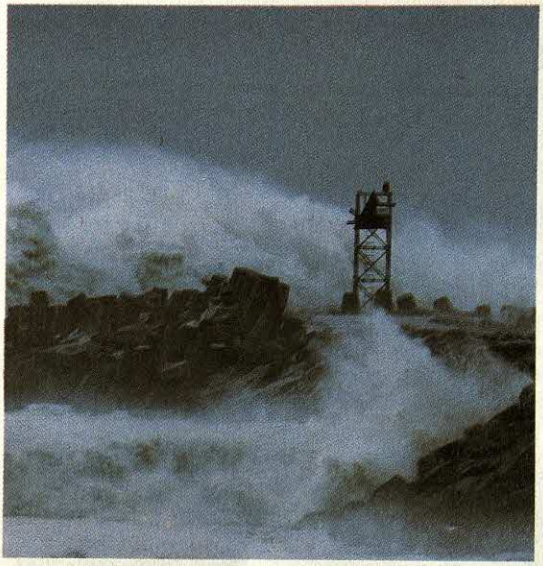
Good personal hygiene and public sanitation are the best methods of preventing the spread of typhoid fever. Effective control of the disease also requires the identification and treatment of carriers. Such measures have made typhoid fever rare in industrial countries.

A vaccine made from killed typhoid fever bacteria provides partial protection for several years. This vaccine is given to people who live in or travel to countries where the disease is widespread.

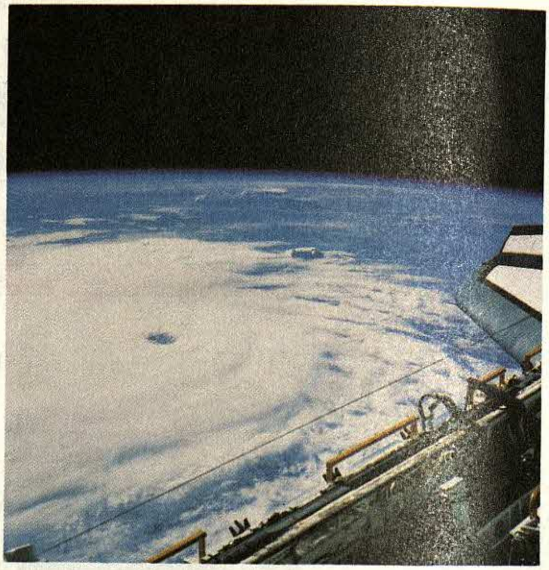
Paratyphoid fever is a disease that resembles typhoid fever in terms of symptoms, spread, and treatment. It results from infection with *Salmonella* organisms other than *S. typhi.*

See also **Typhoid Mary.**

Typhoid Mary was a name sometimes used in referring to Mary Mallon (1868?-1938), the first known carrier of typhoid fever in the United States. She had recovered from the disease but, as a carrier, continued to spread



Huge waves pound a coastline as a typhoon moves onto land. This violent onrush of seawater, called a *storm surge,* can demolish buildings and cause floods, sometimes taking many lives.



Typhoon clouds and winds whirl around the *eye,* a calm area in the centre of the storm. This photograph was taken in 1984 from the space shuttle *Discovery, lower right.*

typhoid fever germs to others. She infected at least 53 persons with typhoid fever between 1900 and 1915. Three of these people died from the disease.

Little is known about Mary Mallon's early life. She was born in Ireland and went to New York, U.S.A., where she worked as a cook. George Soper, a sanitation engineer, connected her to at least six typhoid fever outbreaks in that state. Mallon refused to quit working as a cook, and so she was confined to a hospital. She remained there for over 20 years until she died.

Typhoon is a violent, low-pressure tropical storm that occurs in the western Pacific Ocean. Typhoons are similar to hurricanes (see **Hurricane**). Typhoons begin near the equator and move westward, gathering intensity and size. They advance slowly, usually at about 15 to 25 kilometres per hour. But the circular winds around the centre are very strong, often reaching speeds of 240 kilometres per hour. The diameter of a typhoon can be as large as 480 kilometres.

The heavy rains and powerful winds of a typhoon can cause severe land and property damage and loss of life. A violent and destructive rush of seawater, called a *storm surge,* also often accompanies a typhoon as it moves onto land.

See also **Cyclone.**

Typhus is any one of a group of important diseases caused by *rickettsiae.* These are tiny organisms that look like small bacteria but often behave like viruses (see **Rickettsia**). In human beings, they damage the lining and walls of blood vessels, causing bleeding and skin rashes. Some types of these germs infect animals as well as people. Scientists often call the infected animals "reservoirs" of the disease. Typhus diseases may be transmitted from person to person or from animals to people by lice, fleas, ticks, or mites. There are a number of different forms of typhus, including *epidemic, murine,* and *scrub* typhus and various *tick-borne* fevers.

Epidemic typhus, also known as *classical* or *louse-borne typhus,* is the most important rickettsial infection. It is spread by the human body louse. This typhus has been associated with wars and famines throughout history. Crowding, uncleanliness, and human misery during wartime favour the transfer of infected lice from one person to another. Often, more soldiers died of typhus than in combat. Observers estimated that typhus killed more than 3 million people in Russia during the revolutionary period after World War I (1914-1918). Typhus epidemics occurred in North Africa, Yugoslavia, Japan, and Korea during World War II (1939-1945). Typhus also was common in many Nazi concentration camps. Scientists estimate that about 25 out of every 100 people infected during a typhus epidemic die. Today epidemic typhus occurs in Africa, Asia, and Central and South America.

Primary symptoms of all typhus diseases are headache, skin rash, and stupor or delirium. The patient's temperature may rise to more than 40° C, remain high for three or four days, and then drop rapidly. Complications may include pneumonia and heart and circulatory problems. Recovery is usually slow but in some cases gives complete immunity. However, some people who recover from typhus harbour the live germs in their bodies. Years later these organisms may cause another attack.

Murine typhus, also called *endemic typhus,* is a mild form of the disease. It is transmitted to people by the rat flea. Like epidemic typhus, this disease occurs throughout the world, but does not spread as easily or rapidly. Improved control of rat populations and rat fleas in urban areas has resulted in a sharp decline in the occurrence of murine typhus.

Scrub typhus, also called *Japanese river fever* and *tsutsugamushi fever,* is found throughout Asia and the Western Pacific. It is similar in its effects to epidemic typhus. Scrub typhus is spread by mites called *chiggers.*

Tick-borne typhus is known in many parts of the world, sometimes under local names. Best known is *Rocky Mountain spotted fever,* present in both North and South America. The germ infects the Rocky Mountain wood tick and the American dog tick. The ticks become infected when they bite small mammals, such as field mice and dogs, that are infected with the germ. When the tick bites a person, it transfers the rickettsia to that person's bloodstream. Doctors first discovered the fever in the Rocky Mountain area of the United States.

Treatment. Doctors use antibiotics, particularly the tetracyclines and chloramphenicol, to treat typhus diseases. They also use specially prepared vaccines to prevent the diseases. To control the spread of typhus, particularly during an epidemic, medical personnel often use insecticides on people and on their clothing. This kills the insects that carry the disease.

See also **DDT; Virus.**

Tyrannosaurus was a large, meat-eating dinosaur that lived about 68 million to 65 million years ago in what is now western North America. The name *Tyrannosaurus* means *tyrant lizard.* A tyrant is a cruel, powerful ruler. *Tyrannosaurus* got its name because scientists thought that such a huge beast must have ruled over all other animals, killing whatever it chose. The scientific name for this species is *Tyrannosaurus rex.*

Tyrannosaurus was the largest meat-eating dinosaur. It was about 12 metres long, stood about 3.7 metres high at the hips, and weighed about 6.3 metric tons. *Tyrannosaurus* could rear up to a height of 5.5 metres. However, the animal usually walked with its body parallel to the ground, holding its heavy, muscular tail out behind for balance.

Tyrannosaurus had a huge skull that grew as long as 135 centimetres. The strong jaws had sharp teeth that were about 15 centimetres long. The animal's short, flexible neck and powerful body allowed *Tyrannosaurus* to use its monstrous jaws to rip off large chunks of flesh. The dinosaur's other deadly weapons were the sharp claws on its feet. *Tyrannosaurus* could hold an animal in its jaws and tear at the body with its large claws.

Unlike the rest of the dinosaur's body, its arms were tiny, and its hands had only two fingers tipped with little claws. Although the arms were small, they were strong. *Tyrannosaurus* may have used the arms to push itself up after it had been lying down.

Some scientists have suggested that the huge *Tyrannosaurus* would have moved too slowly to hunt live animals and instead fed on dead animals. But most scientists think *Tyrannosaurus* was an active hunter that could run for short distances. *Tyrannosaurus* may have waited in hiding for a plant-eating dinosaur, such as the duck-billed dinosaur, to get close. *Tyrannosaurus* could then make a quick rush and attack the animal with its sharp teeth and strong jaws.

See also **Dinosaur** (pictures).

Tyranny is a term used throughout history to describe various forms of government by rulers who have unrestricted power. In ancient Greece, for example, *tyranny* simply meant absolute rule by one person. Many Greek tyrants were kind, capable rulers.

The term *tyranny* can also refer to government by an absolute ruler who gained power through military force or political trickery. Such tyrants are not supported by a majority of the people and must use force to maintain their rule.

Another definition of *tyranny* is a government in which a person or a group of people rules in cruel, oppressive, or unjust ways. In many cases, tyrants use their power primarily for their own benefit. Absolute rulers who intend to promote the welfare of society also may be called tyrants if they suppress the freedom of the people. Today, the word *tyranny* is frequently used to describe a dictatorship.

See also **Absolutism; Dictatorship.**

Tyre is a covering for the outer rim of a wheel. Most tyres are made of rubber reinforced with some kind of fabric and are *pneumatic* (filled with compressed air). They are used on aeroplanes, bicycles, buses, cars, earth-moving and mining machinery, motorcycles, recreational vehicles, tractors, trucks, and many other kinds of vehicles. Some rubber tyres, such as those used on wheelbarrows, are made of solid rubber.

The main feature of rubber tyres is their ability to absorb the shock and strain created by bumps in the road. Tyres help provide a comfortable ride and help protect many kinds of cargoes. The air in a rubber tyre supports the weight of a vehicle.

Another important feature of rubber tyres is their ability to grip the road. The face of a tyre, called the *tread,* has many deep grooves. These grooves and many smaller slits called *sipes* make up the *tread pattern.* The tread provides the traction that enables the tyres to grip the road in wet weather. The tyre body is composed of the rubber *side walls* (sides), which cover and protect the rest of the body and are made of high-strength bundles of wire for holding the tyre on the wheel rim. The body also contains layers of rubberized cord fabric. Each layer is called a *ply.*

How tyres are made

Preliminary operations. Before a tyre can be manufactured, several operations must be performed. They include mixing the rubber with sulphur and other chemicals, coating cord fabric with rubber, and cutting the rubberized fabric into strips.

A machine called a *Banbury machine* mixes the rubber with the chemicals. The chemicals strengthen the rubber and increase its resistance to wear. The rubber comes from the machine in the form of sheets.

Cord fabric is made of nylon, polyester, rayon, or steel. A *calendering machine* coats it with the rubber sheeting. The triple rollers of this machine squeeze the cords and the rubber together, producing a rubberized fabric. A cutting machine then slices the rubberized cord fabric into strips of the necessary size.

Assembling a tyre. A tyre is assembled by hand on a slowly rotating roller called a *drum.* The drum has the same diameter as the wheel on which the tyre will be used. As the drum turns, a worker called a *tyre builder* wraps an *inner liner* around the drum. The inner liner consists of a band of special rubber that makes the casing airtight. The tyre builder then wraps the rubberized cord fabric around the drum, ply by ply. Most of today's car tyres have two *belts* of fabric between the plies and the tread. The belts are made of steel or manufactured fibres that resist stretching, such as aramid, fibreglass, or rayon.

After putting on the plies, the tyre builder adds two *beads.* Each bead consists of several steel wire strands that have been wound together into a hoop and covered with hard rubber. A bead is put on the outside of the tyre on each side. It is inserted at the point where the tyre will come into contact with the rim of the wheel. The two ends of each ply are wrapped around the bead, securing the bead to the tyre.

Next, the builder adds the rubber side walls, the belts, and the tread. The various parts of the tyre are then pressed together by a set of rollers in a process called *stitching.*

The *green* (uncured) tyre is now ready to be *vulcanized.* The vulcanization process combines chemicals with the raw rubber and makes a rubber product that is strong, hard, and elastic. The tyre is taken off the drum and placed in a *curing press.* The press contains a large rubber bag called a *bladder* and a mould that has the sipes and large grooves of the desired tread pattern in it. When the press is closed, heat is applied, and the bladder is filled with steam. The pressure of the steam forces the tyre against the mould. The bladder and the mould squeeze the tyre into its final shape, complete with tread pattern. See **Rubber** (Vulcanization).

Today, many of these steps are performed by specially designed machinery. Eliminating hand operations improves productivity and creates a uniform product.

Retreading tyres. After the original tread pattern has worn down, a tyre—if it is in good condition—can be *retreaded,* or *remoulded.* First, a machine rubs away the old tread. Then a worker applies new tread rubber and puts the tyre into a mould. The new tread and tread pattern are then vulcanized to the old tyre. Sometimes a new tread with a pattern that has already been vulcanized is cemented to the prepared tyre body.

Types of tyres and tread patterns

There are two basic kinds of car tyres: (1) *diagonal* or *bias ply;* and (2) *radial,* or *radial ply.* Diagonal or bias ply tyres are commonly known as *cross ply* tyres.

Diagonal or bias ply tyres are built with the fabric cord running diagonally—that is, on the bias—from one rim to the other. Each ply is added so that its cords run at an angle opposite to the angle of the cords below it.

As a vehicle moves, the plies of its tyres rub against each other and against the tread in an action called *flexing and squirming.* This action produces inner heat, one of the major causes of tyre wear. Extreme heat can separate the tread or split the plies.

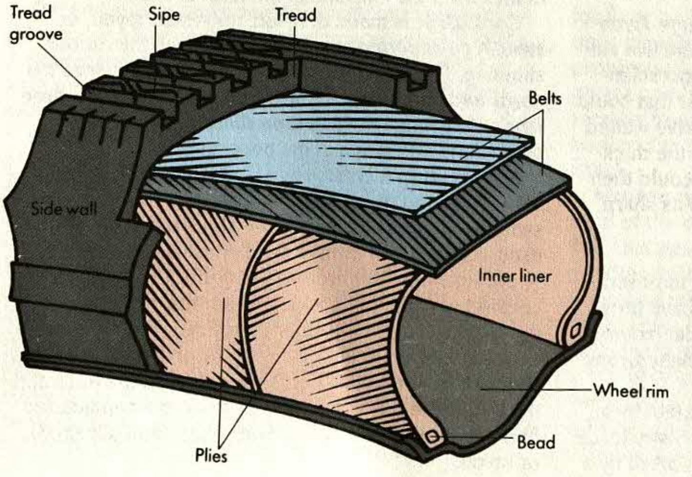
Radial tyres are built with the body fabric cord running straight across the tyre from one rim to the other. All radial tyres are *belted.* Belted tyres have cord fabric belts placed between the plies and the tread. The belts help prevent punctures and fight tread squirm. The combination of radial ply and belting produces a tyre with longer tread life than bias ply tyres. Radial tyres give longer wear because they have less flex and squirm than bias ply tyres. They also roll more easily and thus save fuel.

Low profile tyres are used on many high-performance cars. These tyres look plumper than regular tyres. They are wider (from side wall to side wall) than they are high (from tread to wheel rim). They put more tread into contact with the road than standard tyres. This additional tread creates a wider *footprint* (track), which increases traction. The added stability provided by the tyre shape gives more control at high speeds and around curves than standard tyres give.

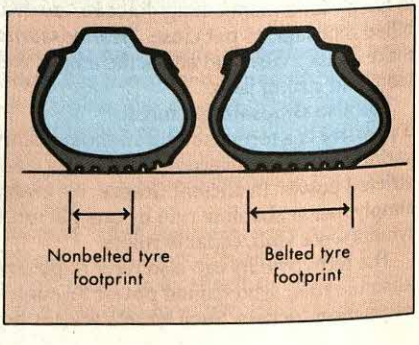
Tyre tread patterns are designed for a variety of special purposes. For example, *snow tyres* have a tread with extra-deep grooves. This tread bites into snow and mud, providing exceptional traction. A snow tyre is not so effective on ice and hard-packed snow because even the deep grooves cannot gain traction. *Studded snow tyres* have metal spikes called *studs,* which stick out of the tyre like small, sharp fingernails. They dig into ice, providing added traction. Some areas have banned these tyres because studies have shown that studs can damage road surfaces. In the 1980's, manufacturers developed tyres for use in any weather. These tyres are

Parts of a tyre

The parts of a tyre, shown below in cross section, are assembled one by one. Starting with the inner liner, a worker assembles the tyre on a slowly turning *drum* (roller). Later, the process of *vulcanization* shapes the tyre, seals the parts together, and moulds the tread pattern of grooves and sipes into the tread.



Tyre belts improve traction and stability and reduce wear by putting as much tread as possible on the road, as shown in the diagram below.



usually called *all-season tyres.* Special tread patterns are also made for the tyres of racing cars, trucks, and various construction, farming, and military vehicles.

Taking care of tyres. Tyres wear out and have to be replaced regularly. A very worn tread pattern on a tyre makes a car unsafe, and driving with excessively worn tread patterns is considered a traffic violation in many countries. The wear on tyres is greater on the traction wheels and therefore it is advisable to exchange the front and back tyres once during their lifetime.

History

The pneumatic tyre was invented in 1845 by Robert Thomson, a Scottish engineer. At that time, most vehicles had wooden wheels and steel tyres. The steel tyres preserved the wood and wore well. Thomson's tyres gave a smoother ride but were not strong enough. In 1870, the first solid rubber tyres appeared in England. These tyres were used on cars and bicycles.

John Dunlop, a Scottish veterinary surgeon, improved on Thomson's invention in 1888. Dunlop developed air-filled rubber tubes for his son's tricycle. These pneumatic tyres provided a smoother ride and made pedalling easier than did solid rubber tyres. Bicycle manufacturers in Europe and the United States soon began to use them.

Pneumatic tyres appeared on cars in 1895. Like bicycle tyres, they were single air-filled tubes. But as cars became heavier and were driven faster, the single tube tyres could not hold enough air pressure for more than a short time. In the early 1900's, two-part tyres were developed. They consisted of a casing and a flexible rubber tube that fitted inside the casing and held the air. This *inner tube* held from 3.9 to 5.3 kilograms per square centimetre of air pressure. These tyres were called *high-pressure tyres.*

Then tyre manufacturers learned that less air in the tyres would not only support the weight of a car but also add comfort to the ride. In 1922, *low-pressure tyres,* or *balloon tyres,* were introduced. They held from 2.1 to 2.2 kilograms per square centimetre of air pressure.

The tubeless tyre was introduced in 1948. Its casing was made airtight by an inner liner. Since 1954, most new cars have been equipped with tubeless tyres.

In the 1970's, manufacturers developed thin, "temporary use" spare tyres that are much lighter and take up less space in the boot than standard tyres. Manufacturers also introduced tyres that would seal themselves if punctured and experimented with tyres that would work even when flat.

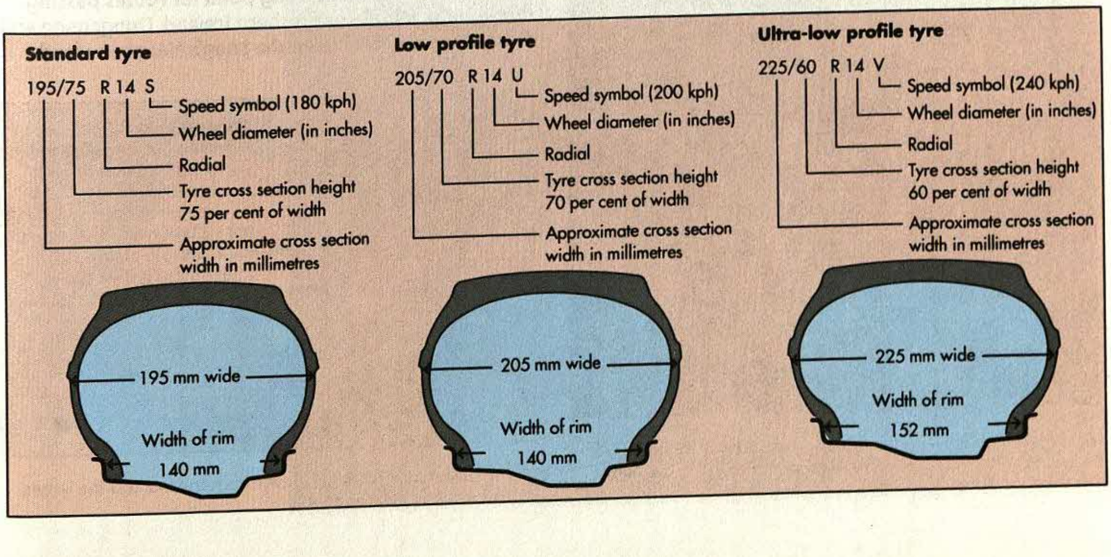
See also **Dunlop, John; Goodyear, Charles; Rubber.**

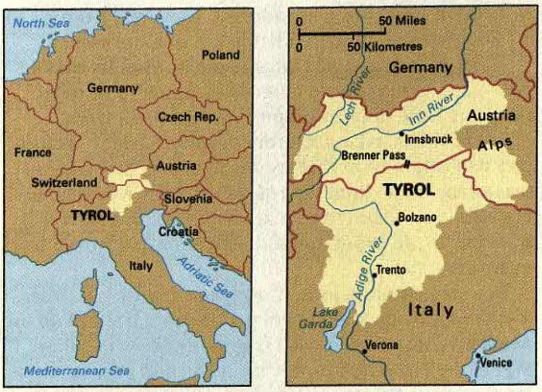
Tyre was an ancient Phoenician seaport. It stood on the Mediterranean Sea in what is now southern Lebanon. Part of the city stood on the mainland and part on an island across a narrow channel. Tyre was an important shipping port, handling goods from Mesopotamia and Arabia. The city was also noted for the purple dye and fine glass that were manufactured there. The people of Tyre were accomplished sailors and were also noted for their cultural and intellectual activities.

Egypt controlled Tyre before about 1100 B.C. Tyrians carried on trade for the Egyptians with the peoples of Asia Minor and the Aegean Sea. The city enjoyed its greatest prosperity between about 1100 and 573 B.C. Part of that time, Tyre was ruled by Assyria, then by Babylonia, and the city was also briefly allied with Israel. Because of its island location, Tyre resisted capture for centuries. Tyrian merchants competed for trade with Greek merchants on the Mediterranean Sea. Tyre founded several trading colonies, including Carthage and Utica on the Mediterranean coast of North Africa and Gades (now Cádiz, Spain), on the Atlantic Ocean.

In 573 B.C., King Nebuchadnezzar II of Babylonia crushed a 13-year Tyrian revolt. Alexander the Great conquered the city in 332 B.C. and built a road from the mainland to the island, creating a peninsula upon which the present town of Tyre stands (see **Lebanon** [map]). Tyre later became a part of the Roman and then Byzan-

Tyre size comparison The size of a car's tyres depends on the type and weight of the vehicle as well as the size of its wheels. Almost all new cars have standard tyres, although many cars now use low profile or ultra-low profile tyres which have better road-holding qualities.


Standard tyre
195/75 R 14 S
Speed symbol (180 kph)
Wheel diameter (in inches)
Radial
Tyre cross section height 75 per cent of width
Approximate cross section width in millimetres
195 mm wide
Width of rim
140 mm
Low profile tyre
205/70 R 14 U
Speed symbol (200 kph)
Wheel diameter (in inches)
Radial
Tyre cross section height 70 per cent of width
Approximate cross section width in millimetres
205 mm wide
Width of rim
140 mm
Ultra-low profile tyre
225/60 R 14 V
Speed symbol (240 kph)
Wheel diameter (in inches)
Radial
Tyre cross section height 60 per cent of width
Approximate cross section width in millimetres
225 mm wide
Width of rim
152 mm



The Tyrol is a region in Europe that includes part of western Austria and northern Italy. The map on the left shows its location. A map of the region itself appears on the right.

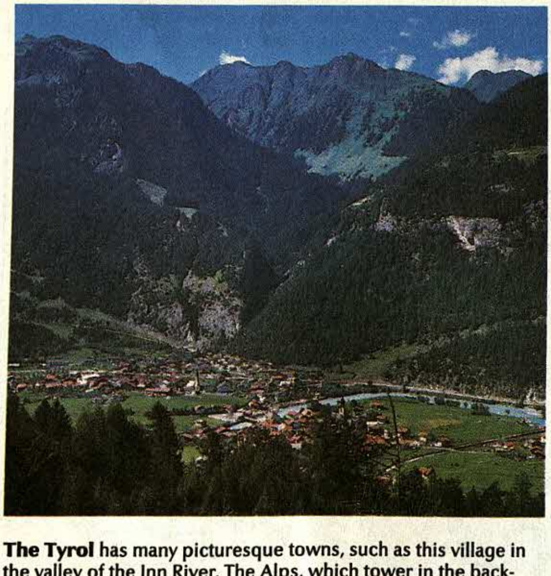
tine (East Roman) empire. Christian crusaders occupied the city from A.D. 1124 until Muslims captured it in 1291.

See also **Phoenicia.**

Tyrol, also spelled *Tirol,* is a beautiful mountainous region in western Austria and northern Italy. The Alps cover most of the area, and they attract many holidaymakers to the Tyrol.

The Austrian Tyrol, or the North Tyrol and the East Tyrol, has an area of 12,647 square kilometres and a population of about 631,000. It is a province of Austria. The Italian Tyrol, or the South Tyrol, is known as *Trentino-Alto Adige.* It extends south from the boundary of Austria and is divided into the provinces of Bolzano and Trento. It covers 13,613 square kilometres. About 870,000 people live in the area.

The Romans conquered the Tyrol in 15 B.C. Later, the region fell into the hands of various Germanic tribes. In 1363, it became part of Austria. After World War I (1914-1918), the northern part of the Tyrol became a province of the Austrian republic. The southern Tyrol was given to Italy. The Italians promised political and cultural autonomy to the large German-speaking minority in the Italian Tyrol, but the Fascist government of Italy suppressed the use of the German language in the area.



The Tyrol has many picturesque towns, such as this village in the valley of the Inn River. The Alps, which tower in the background, make the Tyrol a popular skiing area.

After World War II (1939-1945), in spite of Austrian objections, the southern Tyrol was again given to Italy. By an agreement signed with Austria, Italy promised autonomy for German-speaking South Tyroleans. In the late 1950's, these people said they did not have autonomy and began fighting for it. In 1971, the southern Tyrol conflict was settled after Italy granted the region a large amount of autonomy.

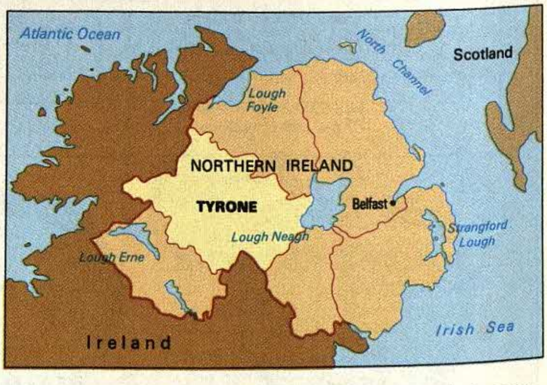
See also **Alps; Austria** (picture: A centuries-old festival).

Tyrone is the largest of the six counties of Northern Ireland. It has an area of 3,263 square kilometres. In 1973, Tyrone was divided into the local government districts of Dungannon, Omagh, and Strabane, and part of the district of Cookstown.

Tyrone is an inland county, bounded by County Londonderry to the north, Lough Neagh to the east, County Armagh to the southeast, and the border with the Republic of Ireland to the south and west. The central part of County Tyrone consists of flat, low-lying bog and moorland. In the north, the summit of Sawel in the Sperrin Mountains rises to 683 metres. In the south, the local rock consists mostly of sandstone and limestone. The upland and boggy areas are infertile. But there are fertile valleys drained by the Blackwater and Ballinderry rivers, which flow eastward into Lough Neagh. In the west, the Glenelly, Owenkillew, and Strule rivers form a system of waterways that combine in the Mourne River to flow through the town of Strabane and into the Foyle above its wide estuary. The Clogher Valley in south Tyrone is extremely fertile and crosses the best woodland and agricultural land in the county.

Economy. Tyrone is mainly a farming county. Its hundreds of small farms are devoted to cattle and dairy produce. They also grow oats, barley, potatoes, and grass seed.

Chief towns. Omagh, the former county town and administrative centre of County Tyrone, has a fine courthouse. The town is a meeting point for routes passing through the middle of Northern Ireland. Dungannon and Cookstown are situated in the Lough Neagh lowlands.



Tyrone is an inland county in Northern Ireland. It is the largest of the country's six counties.

Omagh is the former county town and administrative centre of County Tyrone. It stands at the confluence where the Camowen and Drumragh rivers join to form the River Strule. It is a manufacturing and market town and serves as a base for tourists and anglers.

Dungannon was once the centre of an extensive linen industry. The coalfield from which Coalisland takes its name is no longer worked. But the clays associated with the coalfield are still used in the local brick-making industry.

Clogher is a small cathedral town, the seat of both a Church of Ireland and a Roman Catholic bishop. Other small towns are Stewartstown, Fintona, Strabane, and Auchnacloy.

History. Tyrone has many prehistoric monuments. They include tombs of the pre-Gaelic inhabitants of Ireland. The county takes its name from the Irish *Tir Eoghain,* which means the land of Eoghain, or Owen. Owen was the son of Niall of the Nine Hostages, a famous king of Ulster in pre-Christian times.

From the 400's to the 1500's, Tyrone was the centre of the territory ruled by Niall's descendants, the O'Neill family. Successive chieftains of the O'Neills held court at Tullyhogue, near Dungannon. Until the reign of Queen Elizabeth I, this part of Ulster remained the most Gaelic area of Ireland, and it was the last to fall under English influence.

The great Hugh O'Neill, an Irish chief who was brought up in England, rebelled against Elizabeth I at the end of the 1500's. After nine years of war, O'Neill surrendered in 1603, unaware that the Queen had died only a few days earlier. His surrender marked the end of Gaelic resistance in Tyrone, and the coronation stone of the O'Neills at Tullyhogue was broken by the English commander, Mountjoy. Hugh O'Neill accepted the English title of Earl of Tyrone, and agreed to the replacing of the Irish Brehon law by English law. But in 1607, with his ally, Hugh O'Donnell, Earl of Tirconnell (Donegal), he suddenly fled to Spain. This event, which is called the

An imposing courthouse is one of Omagh's most distinguished buildings. Built in the 1700's, it is designed in an austere version of the neo-classical style favoured by the Georgian architects who were influenced by the work and theories of Palladio.

St. Teresa's Church at Sion Mills, County Tyrone, was built in 1963. The facade has a large, stylized drawing of the Last Supper, engraved by Oisín Kelly.

Cheese production and dairy farming are important economic activities in County Tyrone. The factory shown above is in the Clogher Valley, in Dungannon district.

"Flight of the Earls," opened the way for King James I's Plantation of Ulster, in which English and Scottish colonists were given grants of land in the north of the island of Ireland.

After the "Flight of the Earls," the vast O'Neill estates were taken over by the British Crown, and portions of them were granted to Scottish and English "Undertakers," who agreed, or undertook, to "plant" them with their own tenants. They were not able to do this completely, and many of the original Irish inhabitants remained on the lands as tenants. This fact is partly responsible for the religious and political divisions of the county today.

At Benburb, in 1646, a Scottish army led by General Robert Munro was totally defeated by the Irish under Owen Roe O'Neill. In 1782, Dungannon was the setting for one of the most famous events in Irish history, when the delegates of 143 regiments of the Irish Volunteers met in the parish church to demand the independence of the Irish parliament. This meeting enabled Henry Grattan and his Irish "patriots" to form a shortlived Irish parliament that was ended by the Act of Union in 1800.

Tyrone, Earl of (1540?-1616), Hugh O'Neill, was the leader of an Irish rebellion against the English during the reign of Queen Elizabeth I. The revolt began in 1594. In August 1598, Tyrone defeated the English at Yellow Ford, and the rebellion spread to the other Irish provinces. In 1601, Spanish forces came to the aid of the Irish. Lord Mountjoy, commanding an English army, defeated the combined Irish and Spanish armies and forced Tyrone to surrender in 1603.

Tyrothricin. See **Dubos, René J.**

Tyrrell, Joseph Burr (1858-1957), was a Canadian geologist, historian, and mining engineer. He conducted studies during several expeditions in northwestern Canada that aided the development of the Canadian mining industry.

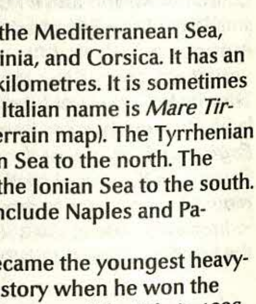
Tyrrell was born in Weston, near Toronto, Ontario. He graduated from the University of Toronto in 1880 and joined the Geological Survey of Canada in 1881. In 1884, near Drumheller, Alberta, Tyrrell discovered the first dinosaur bones ever found in Canada. Shortly afterward, he found one of the nation's largest coal deposits nearby. Tyrrell joined the Kirkland Lake Gold Mining Company in 1924 and served as president of the firm from 1931 until his death.

Tyrrhenian Sea an arm of the Mediterranean Sea, lies between Italy, Sicily, Sardinia, and Corsica. It has an area of about 155,400 square kilometres. It is sometimes called the Tuscan Sea, and its Italian name is *Mare Tirreno.* For location, see **Italy** (terrain map). The Tyrrhenian Sea connects with the Ligurian Sea to the north. The Strait of Messina links it with the Ionian Sea to the south. Principal ports on its shores include Naples and Palermo.

Tyson, Mike (1966-), became the youngest heavyweight champion in boxing history when he won the World Boxing Council (WBC) version of the title in 1986. Tyson was 20 years old when he won the championship.

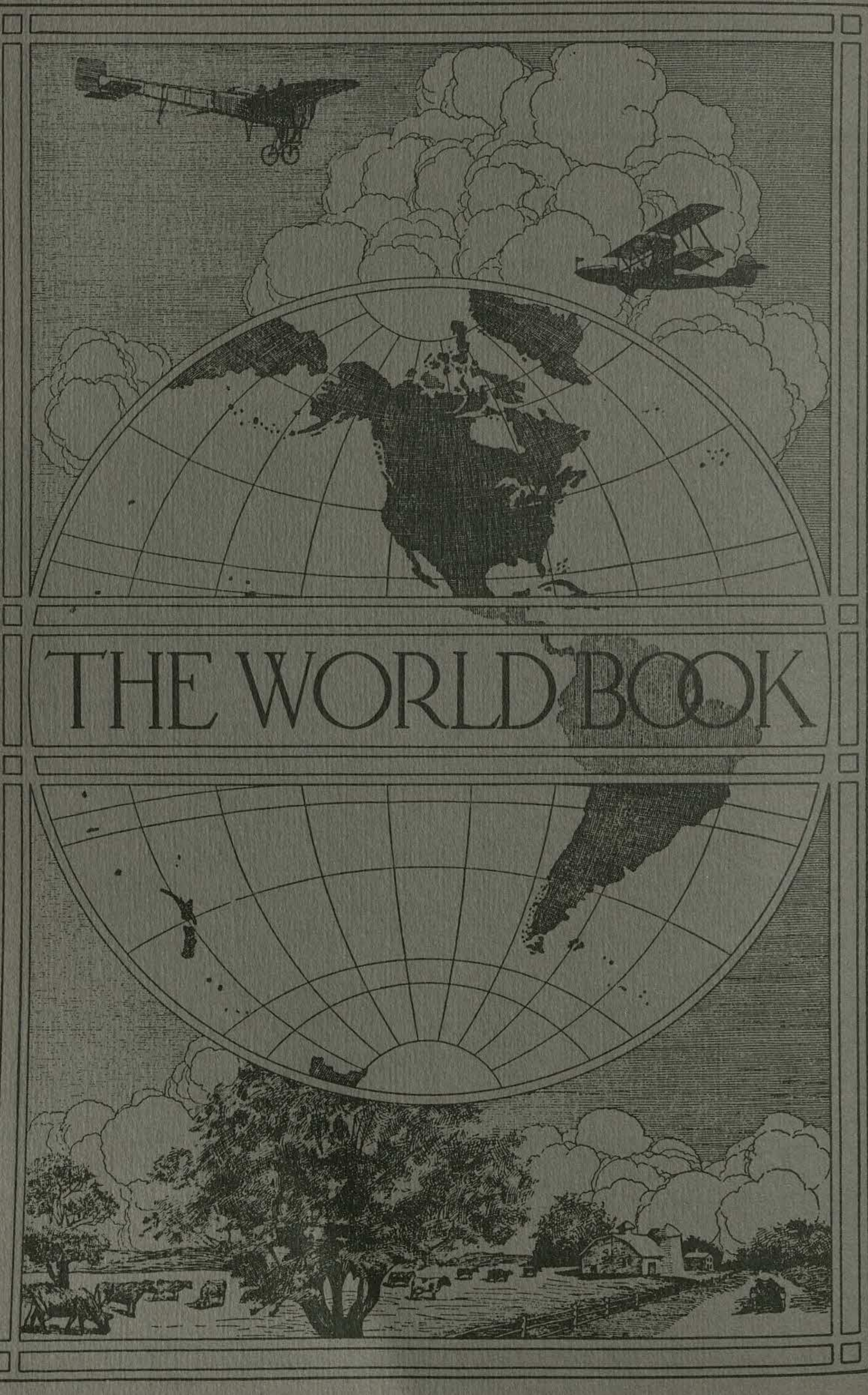
He became the undisputed champion in 1987 by also winning the World Boxing Association (WBA) and International Boxing Federation (IBF) versions of the title. Tyson lost the championship in 1990 when he was knocked out by Buster Douglas. Tyson had been undefeated, winning 37 consecutive fights, 33 by knockouts.

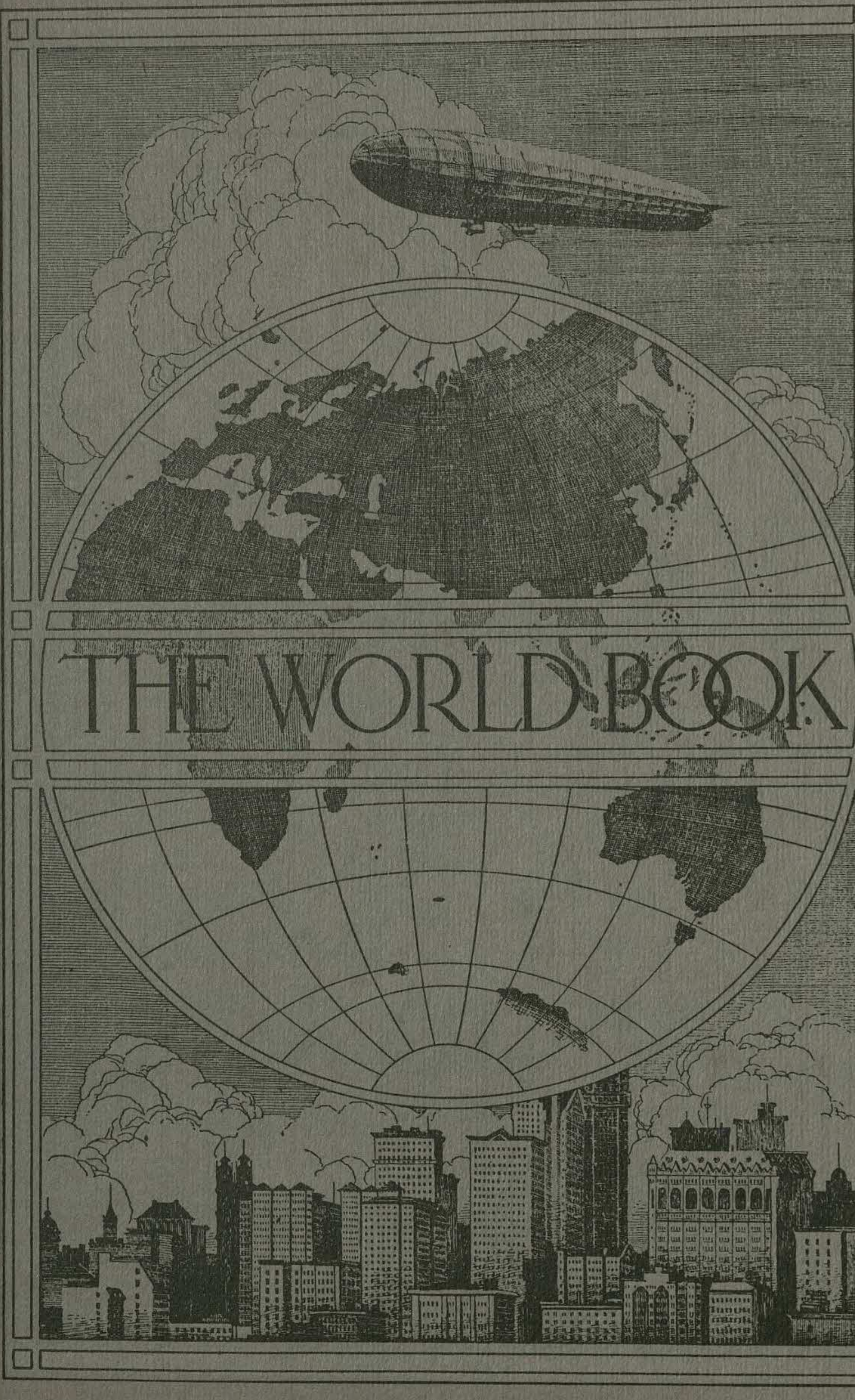
Michael Tyson was born in Brooklyn, New York City. He began boxing at the age of 13 and became a professional fighter in 1985. He was convicted on a charge of rape in 1992, and imprisoned. Tyson stands 182 centimetres tall and weighs about 100 kilograms. He became known for his powerful punches and his aggressive pursuit of his opponents.



Mike Tyson

Tywi. See **Towy.**


THE WORLD BOOK


THE WORLD BOOK

THE WORLD BOOK